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BUILDING CONSTRUCTION AND DRAWING.

BY

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ASSISTED BY

GEORGE A. MITCHELL,

Honours Medallist Building Construction, National Silver Medallist
Carpentry and Joinery, &c.

FIRST STAGE OR ELEMENTARY COURSE.

Compiled to assist Students preparing for the May Examinations of the Science and Art Department, the Royal Institute of British Architects, the Surveyors' Institution, the City Guilds, Civil Service, and other Examinations.

Fourth Edition, Revised and Enlarged.

(SIXTEENTH THOUSAND.)

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PREFACE

TO THE FOURTH EDITION.

The constant and increasing demand for this little work has enabled me from time to time to make various improvements both in the text and the illustrations, but not until now have I been able to avail myself of the opportunity (a new edition being called for) to thoroughly revise it—bringing it up-to-date.

I have systematised the Chapter on Drawing so as to satisfy the most modern requirements, and have materially improved those on Brickwork and Masonry. Further, I have replaced obsolete joints in Carpentry by more modern construction, and have made additions to the Chapters on Ironwork, Carpentry, and Plumbing.

Thus it will be seen that much of the text and many of the figures have been revised in this edition, some pages of new matter and illustrations have been added, and I trust that the usefulness of the book will be increased by these alterations.

Charles F. Mitchell.

The Polytechnic Institute,
308, Regent Street, London, W.
October, 1897.

PREFACE

TO THE FIRST EDITION.

It has been my duty, with my respected colleague the late A. Harland, Esq., A.R.I.B.A., to prepare great numbers of students for the Annual Examinations in Building Construction in the Elementary, Advanced, and Honours Stages, and we felt the great need of a text-book, with illustrations fully dimensioned, containing the latest practice, and that had been thoroughly revised by specialists in each of the building trades. With this object in view, and having the co-operation of my fellow teachers of the Polytechnic Institute, I have compiled this work, *primarily for our own students*, but trusting that it will be found useful to those in other classes, and to all persons connected with the building trades.

I take this opportunity to thank J. W. Clarke, lecturer on "Plumbing"; G. C. Pope, teacher of "Practical Carpentry"; H. W. Richards, lecturer on "Brickwork and Masonry"; H. J. Spooner, C.E., F.G.S., lecturer on "Engineering"; E. A. Young, lecturer on "Building Construction," for the great assistance rendered in revising the chapters against which their names are placed on page viii, and to E. G. Davey for his valuable assistance in preparing illustrations.

Charles F. Mitchell.

October, 1888.

LIST OF WORKS, ETC.,

REFERRED TO.

In compiling this treatise the author is pleased to acknowledge his indebtedness to the authors of the following works, which he has consulted :—

"Encyclopædia of Architecture"	Gwilt.
"Building Construction"	Harland, A.
"Architectural Surveyors' Handbook"	Hurst.
"Pocket Book of Engineering Formulæ"	Molesworth.
"Carpenter and Joiner's Assistant"	Newland.
"Practical Builder"	Nicholson.
"Notes on Building Construction"	Rivington.
"Builders' Work"	Seddon, Col. H.
"Carpentry, by Hurst"	Tredgold.
"Instruction in Construction"	Wray, Col. H.
Science and Art Examination Papers.	
The "Builder."	
The "Building News."	
"New Technical Educator"	Cassell & Co.

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CHAPTER I.

INSTRUCTIONS FOR BEGINNERS.

INSTRUMENTS AND MATERIALS.

The following instructions to beginners are among those given at the Building Classes held at the Polytechnic, Regent Street, London, W.

The student should bear in mind that it is better to have a few instruments which are good than a greater number that are inferior, and he would find it to his advantage to buy his instruments separately from some good maker or firm, rather than purchase a complete set of inferior quality, which will be sure ultimately to prove unsatisfactory. If this method of acquiring a good set be adopted, a good way of keeping the instruments in good order, when required to be carried about, is to have a roll made of chamois or wash-leather, with separate compartments for each instrument, such as are often made in leather for pocket sets of tools.

The following instruments should be obtained :—Compasses with ink and pencil points (those with double-jointed legs and needle points are much to be preferred), dividers, ruling-pen, and two set squares, 45° and 60° respectively. These set squares had better be of vulcanite ; if made of pear-wood they shrink, and are then useless, as the angles are no longer true, and good and neat work cannot then be done with them.

A set of spring bows (consisting of dividers, pen, and pencil bows) is also to be recommended for small work, but are not absolutely necessary. It is better for these not to be provided with needle points, as they cannot in this case be used for extremely fine work, and the draughtsman cannot easily see if the point be placed in the exact position.

To prevent corrosion, great care should be taken to clean all instruments after having been used.

Drawing board of yellow pine, the minimum dimensions of which should be 24 inches by 18 inches, $\frac{3}{4}$ inch thick, secured at the back with battens so arranged as to permit of the board shrinking without splitting.

T-square, 24inches long, with bevelled ebony edge, so made that the set-square can pass freely over the head.

HB pencil for notes, H and HH pencils for drawings, india-rubber, four good drawing-pins, sharp penknife, a box of colours, and glue. Cake colours are preferable for technical drawing, and the student will find it to be to his advantage to obtain these also of good quality.

A set of boxwood scales is also required; as these are expensive, their use is to a large extent replaced by sets of paper scales, such as the Polytechnic technical scales, sold by the publishers of the present work, which, having only one scale on each edge, prevent the student falling into mistakes common to the use of boxwood scales with two or more scales on each edge; the cost of the paper scales is also considerably less.

Pencil Sharpening.—A sharp paring chisel is about the best tool for this purpose, but such tools are not always convenient, and therefore a sharp penknife should be used. For ordinary use a round point should be made, as shown in figure 1, but for drawing lines against straight edges, especially with the harder pencils, a chisel point, as shown in figure 2, may be advantageously used, as it will retain its edge longer.

Drawing Paper.—The following are the sizes in general use, although the exact dimensions vary slightly with different manufacturers :—

	Inches.
Demy	20 by 15½
Medium	22 ,, 17½
Royal	24 ,, 19½
Imperial	30¾ ,, 22
Double Elephant	40 ,, 27

Whatman's (*not* hot pressed), medium thickness, is a quality to be recommended for finished drawings; it will stand wetting and stretching without injury, and when so treated receives shading and colouring easily and freely. Whatman's *hot pressed* paper is useful for exhibition pen-and-ink drawings, but great care must be exercised to prevent any mistakes, as it does not readily admit of alterations. The proper face of the paper upon which to draw is that side on which, it being held to the light, you can read the maker's name. For ordinary working drawings and details, cartridge paper, which is cheaper, may be used, when damp-stretching is dispensed with, and no large washes of colour are required.

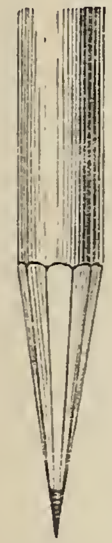


Fig. 1.

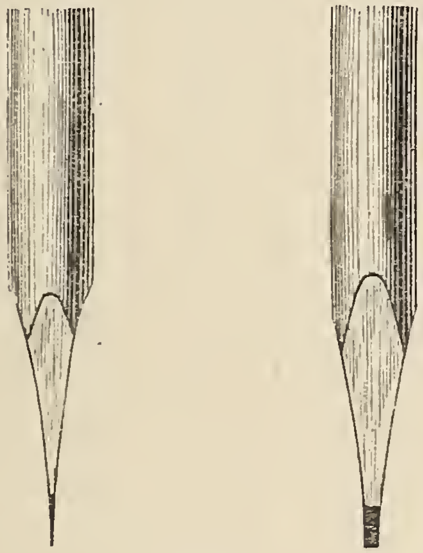


Fig. 2.

Damp Stretching.—If the paper is to be used for a highly-finished drawing it must be very firmly attached to the board, and nothing is more suitable for the purpose than glue, such as Higgins' vegetable glue. The stretched irregular edges of the paper are first cut off. The paper should then be thoroughly saturated on both faces, but if one face only is damped, it should be the upper one, as any dirt may be easily sponged off. A wide brush or clean sponge should be used, the edges of the paper being first thoroughly damped all round, and then the whole surface. The edges of the paper should not be quite as damp as the other parts of the surface. After the paper has been thoroughly damped, it must be left until the gloss entirely disappears; it is then turned over and placed in position on the board. Next, about three-eighths of an inch is turned up at the edge against a flat ruler or straight-edge, and a glue brush with glue passed between this turned-up edge and the board; the ruler is then drawn over the glued edge and pressed along. If the paper be found not to be thoroughly close when the ruler is removed, a paper-knife passed along the edge will remedy this. The next adjoining edge must be treated in a similar manner, then the next, and the next. When dry, the paper should present a perfectly plain surface for drawing and colouring upon. When the drawing is completed, the paper is cut with a penknife or cutting gauge; the glued margin on the board should be carefully cleaned off with a sponge and cold water. On no account must the edge of a **T**-square be used for cutting against.

Centre and Datum Lines.—If the work to be produced offer any opportunity for using centre lines, draw them at the commencement, with chain dotted lines. Especially should this be noted whenever window or door openings, columns, or any symmetrical details occur. These will be found of great convenience whenever any dimension is called into question, or whenever any reference or readjustment has to be made. If the drawing does not lend itself to be set out from centre lines, some important plane surface, such as floor levels, wall plate levels, etc., which should be drawn, and any line could be measured from the same. If, however, there be no such important surface or line, which is of rare occurrence, the best thing to do is to make an imaginary one, and let all measurements bear a relative position to it. These important plane surfaces or lines are known as datum surfaces or datum lines.

Scale Construction.—If the drawing is to be to an unusual scale, say 5 feet to 2 inches, construct one in the following manner:—

Draw an indefinite straight line, AB, and mark off 2 inches, AC. Draw line AD at any convenient angle, and from A on

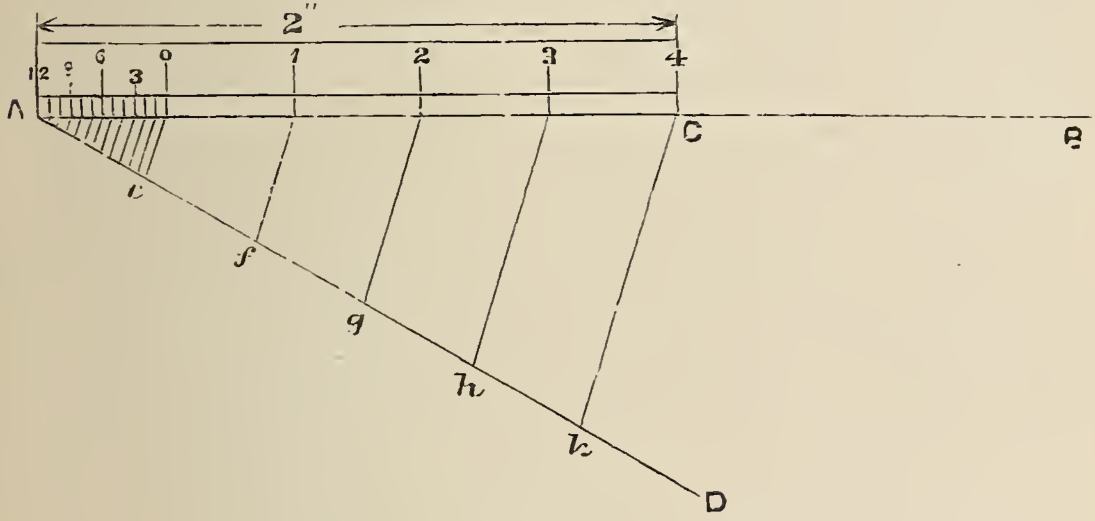


Fig. 3.

line AD, with dividers opened to any suitable distance, mark 12 equal divisions A to E; open dividers to distance AE, setting out four equal distances, FGHK. Join KC, and from divisions draw parallels to KC, dividing the line AC; then complete the scale as shown in figure 3. If the divisions on the line AD can be conveniently set off direct from a scale, this method is to be preferred, and, as a rule, mark off dimensions with a scale direct, and thus avoid the unnecessary use of compasses for that purpose.

All drawings on completion should have a scale drawn at the bottom, or in the lower left-hand corner, or wherever it is most convenient, so that dimensions can be measured from same at any time, the scale and drawing being then equally affected by the contraction and expansion of the paper, which is often a material quantity.

Inking in.—Always use good Indian ink, rubbed up in a smooth china saucer. Ordinary ink, which runs when drawings are coloured, must on no account be used, as many drawings when coloured are spoilt by the ink running, through neglecting this precaution. However, should this happen, it may be remedied by immediately washing the whole drawing with plenty of clean water, which will remove all free ink. The water must be carefully removed by means of a piece of clean blotting paper. To ascertain if the ink is sufficiently mixed for use, blow in the saucer or palette, or make a line on paper and smear it; if by either method the ink exhibits a brownish tint instead of a black, it is not mixed sufficiently.

Erasure of Lines.—Inked lines may be eliminated as follows:—Take a clean piece of paper and place it over the lines that are to be removed, cutting away a portion of the clean sheet just sufficient to enclose them; then with a clean sponge the lines may be washed out, the remaining portion of the drawing being protected by the covering paper.

Cleaning out pencil lines with india-rubber must be done in one direction, as rubbing backwards and forwards destroys the surface of the paper. Drawings, if dirty, should be cleaned with stale bread in preference to india-rubber.

Hatching Sections.—When the drawings are not to be coloured, the materials most commonly used may be denoted in section by lines as shown in figures 4 to 14.

Colouring.—When a drawing is to be coloured, no sectional nor hatching lines are to be drawn; the same colour as that used for elevations, but of a darker tint, is to be laid on for sections, unless otherwise stated.

List of Conventional Colours to be used in Preparing Drawings:—

Burnt Sienna.—Fir, wrought (except floors), roads, and gravelled surfaces.

Burnt Umber.—Oak, terra cotta.

Cobalt.—Glass (seen from within).

Crimson Lake.—Brickwork in plan and section, lines on which sections are taken, centre and datum lines.

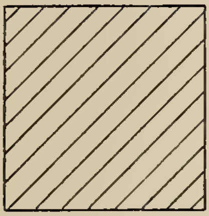


Fig. 4.—Brick.

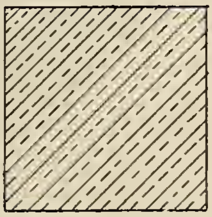


Fig. 5.—Stone.

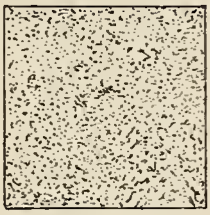


Fig. 6.—Plaster.

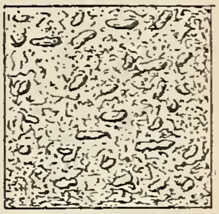


Fig. 7.—Concrete.

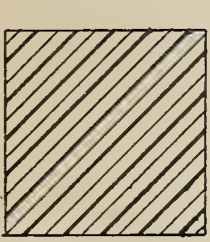


Fig. 8.—Wrot. Iron.

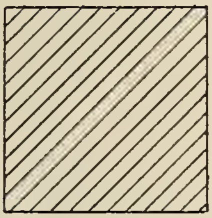


Fig. 9.—Cast Iron.

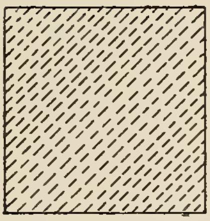


Fig. 10.—Steel.

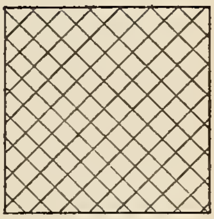


Fig. 11.—Lead.

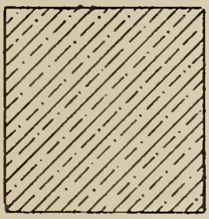


Fig. 12.—Brass.

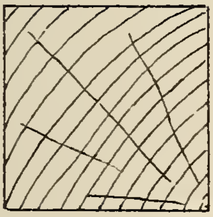


Fig. 13.—Wood.

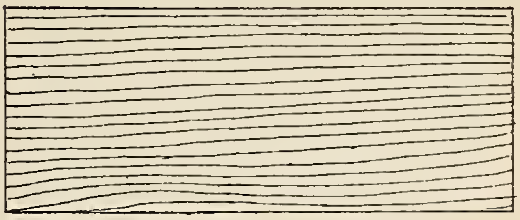


Fig. 14.—Wood—Longitudinal Section.

Gamboge.—Brass, proposed alterations or additions to existing plans.

Hooker's Green, No. 2.—Glass in section, grass.

Indian or Chinese Ink.—Lines generally, lettering, shading to slopes of roof; existing timber and old work (pale).

Indigo.—Lead, glass (seen from without), hard stone in dressings, floors, steps.

Indian Yellow.—Gun-metal.

Neutral Tint.—Concrete, speckled with Indian ink; shadows and flat washes to show retired planes of buildings—the deepest for the most distant; slates in roofing, etc., stone walling (light in elevation); plaster (in section).

Payne's Grey.—Cast-iron.

Prussian Blue.—Wrought-iron, water, dimension lines, plaster in elevation (very pale).

Raw Sienna.—Deal floors, fir unwrought, buff brickwork (in elevation), with the addition of a few lines of burnt sienna.

Sepia.—Earth (in section); asphalte (a light tint speckled with Indian ink).

Vandyke Brown.—Freestone masonry in dressings, etc. (very pale).

Venetian Red.—Copper, red brickwork (in elevation), with the addition of a few lines of crimson lake; tiled floors, roofs, etc.

For the convenience of those whose colours are limited, the following mixtures may be used in place of some of the colours given above:—

Burnt Umber.—Vandyke brown (or sepia) and burnt sienna.

Indian Yellow.—Gamboge and pale burnt sienna.

Hooker's Green.—Prussian blue and gamboge.

Payne's Grey.—Indigo, Indian ink, and crimson lake.

The following mixtures are used for indicating the materials whose names are placed against them:—

Blue Bricks.—Indigo and Indian ink.

Greenheart.—Indigo and gamboge.

Mahogany.—Crimson lake and sepia.

Steel.—Prussian blue and crimson lake.

It is usual before colouring to ink in the lines of architectural drawings, as alterations after colouring disfigure the work. If the ink is of good quality it is not necessary to damp the paper before colouring, unless there are large washes. Light colours should precede dark ones. Colour all parts to be of the same tint, straightway, taking care to mix sufficient colour, as it is very difficult to match exact shade. Avoid the mistake of mixing colours of too dark a tint; at the same time it is not well to put two washes of colour upon the same part. Sable or camel-hair brushes should be used, and care must be taken to select such as have a good sharp point and not a long straggling one.

Dimensions.—All the leading dimensions should be distinctly figured in. Inattention to this precaution may produce serious mistakes. The extent of the dimensions should be shown by neat arrow-heads connected by a continuous thin blue line broken only in the middle, the dimensions being inserted in this space in a vertical position, and all to read one way. Internal dimensions should be taken between the brick or stone walls, also between floor levels.

Lettering.—For titles and headings, Egyptian or block upright letters are effective. Roman letters are satisfactory and easier to form, while for general and descriptive writing an easily written form of neat italics is to be preferred.

Specimen Upright Block—Capitals.

A B C D E F G H I J K L M N O P Q
R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 0

Specimen Upright Block—Small.

a b c d e f g h i j k l m n o p q
r s t u v w x y z

SPECIMEN UPRIGHT ROMAN—CAPITALS.

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z

SPECIMEN UPRIGHT ROMAN—SMALL.

a b c d e f g h i j k l m n o p q
r s t u v w x y z

SPECIMEN—ITALICS.

a b c d e f g h i j k l m n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0

Geometrical Explanations—Measurements.—Throughout these lessons a single accent (′) signifies feet, a double accent (″) inches, and (°) degrees.

Plan.—If the boundaries of the surfaces of solids are imagined to be projected in paths, or by lines perpendicular to a horizontal plane, that portion of the horizontal plane enclosed by the projectors is called the plan, and thus there may be roof plans, floor plans, basement plans, etc.

Elevation.—In a similar manner the space covered on a vertical plane by projectors, from a solid, perpendicular to the vertical plane, is the elevation; and therefore front elevations, back elevations, side elevations, etc., are so called after the sides seen.

Section.—When a plane divides a solid, the cut surfaces are called sections, and there may be cross (or transverse) sections, longitudinal sections, vertical, and horizontal sections.

Sectional Plans or *Elevations* are the projections of a cut surface and any remaining uncut part of the solid.

The parts seen from the outside in plan or elevation (always being perpendicular to the plane that projectors are being taken from) are drawn in firm lines, those "unseen" in dotted lines, to indicate their position.

Isometric Projection.—It is often convenient, especially for details of solids with rectangular faces, to show the three dimensions in one view. This may be accomplished by drawing three lines meeting in a point containing equal angles of 120°, representing length, breadth, and depth, to scale, and from the free extremities of these lines draw lines parallel to the other two. It is usual to work with ordinary scales.

Perspective Drawing.—This is the science of making representations of objects as they appear to the eye, and is very useful for showing how a proposed object will appear when made, and for illustrating details.

Tracing.—An original drawing is made of all proposed work; from this standard drawing a number of copies are often required to be made. The copies are made by tracing or by photography.

For comparing the plotting of different stories during the process of designing, tracing paper is commonly used, but copies of drawings that are to be much used are usually traced upon linen which offers a greater resistance to tearing. The glazed side is usually inked and the coloured washes placed upon the back. There is often a difficulty in getting the ink to flow uniformly upon the glazed surface of the linen, but to overcome this obstacle a little oxgall is mixed with the ink; or chalk may be rubbed upon the glazed surface of the linen for the same purpose.

Black Line, Water-bath Reproduction.—A drawing is made upon very clean tracing paper or tracing cloth. The tracing is placed against the glass of a printing frame (such as is used in photography) in front of specially prepared sensitized paper in a dark room, and the frame is then closed and exposed to the direct and uninterrupted rays of light.

Sufficiency of exposure is indicated when the blank surface of the sensitized paper (that is, the part not covered by the ink lines on the tracing) turns from the yellow to the natural whiteness of the back of the sensitized paper. Then the print is held under running water till the black lines are developed, and the yellow coating which turns black on contact with the water is washed away.

The required exposure ranges from 5 minutes in bright sunshine to 1 hour in dull weather.

This method is now extensively used.

CHAPTER II.

BRICKWORK.

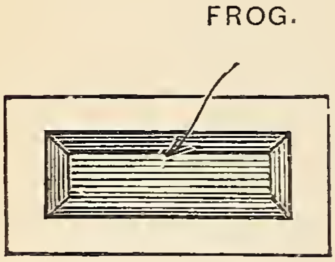
Definition.—Brickwork is the art of arranging and bedding bricks in either lime or cement mortar to unite and form a homogeneous mass of a desired shape with sufficient stability to resist safely the stresses to which it is to be subjected.

Stability of Brickwork.—There are three general ways in which the stability of brickwork may be affected :—1st, by concentrating too great a weight on a given area of ground, or by the ground being soft, or inclined to slide, in which case the walls are thrown out of the upright, crack, or disintegrate, see Chapter on Foundations, Part 2. 2ndly, by being badly bonded, in which case there will be no tie between the bricks, and disintegration follows ; this may be remedied by bonding according to the arrangements shown later. 3rdly, by insufficient transverse resistance, which may be compensated for by building all walls of a thickness proportional to their height, by preparing for all side thrusts or wind stresses, by taking care that all courses are bedded truly, and if likely to be thrown under a tensile stress that they be bedded in some tenacious mortar.

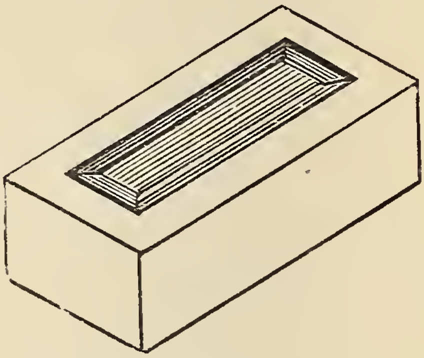
Technical Terms.—The average size of a good stock brick is 8¾″ long, 4¼″ wide, and 2¾″ thick, and the dimensions, including one mortar joint, in this work, unless otherwise stated, will be taken as, length 9″, width 4½″, and thickness 3″. Bricks are usually bedded on the 9″ × 4½″ surface in lime or cement mortar, the upper large surface having an indentation, or frog, as it is sometimes called, which affords a good key for the mortar, as shown in figures 15 and 16.

Bricks are wetted before being used in order to remove loose dust, to afford better adhesion for the mortar, and to prevent the bricks absorbing too much moisture from the mortar.

Course is the name given to the row of bricks between two bed joints, and the thickness is taken as one brick plus one mortar joint, in this work; unless otherwise stated it will be considered as 3″, or, as technically described, four courses to the foot.



PLAN OF BRICK.
Fig. 15.



SKETCH ELEVATION.
Fig. 16.

Bed Joints are those mortar joints between the courses :—

(*a*) In walls with vertical faces the bed joints would be horizontal.
(*b*) In batter walls they would be at right angles to the batter.
(*c*) In arches they come between the voussoirs.

Quoins are the external corners of walls. The name is sometimes applied to the bricks or stones which form the quoins, *e.g.*, quoin brick, quoin stone.

When the vertical joints of the face of the wall fall immediately over each other the "perpends" are said to be kept.

Stretchers are bricks laid with their lengths of $9''$ on the face of the wall or parallel to the face of the wall.

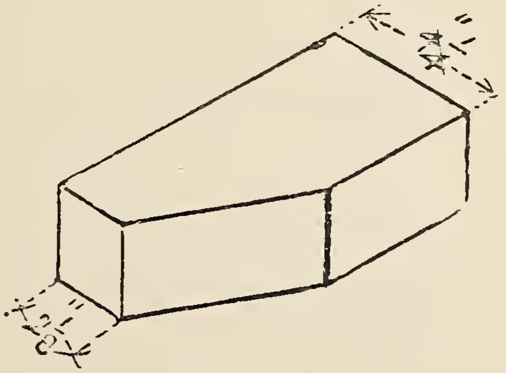
Headers are bricks laid with the width of $4\frac{1}{2}''$ on the face of wall or parallel to the face of the wall.

Bats are pieces of bricks, and are usually known according to their proportion to whole bricks, as $\frac{1}{2}$ or $\frac{3}{4}$ bats.

Lap, the horizontal distance between the vertical joints in two successive courses. This should be $2\frac{1}{4}''$.

Queen Closers are bricks made the same length and thickness as ordinary bricks, but half the width. Owing to the quantity broken in cartage, the extra expense is usually an objection, and bricklayers form the closers economically by cutting their broken bricks into $\frac{1}{4}$ brick bats and placing two together to form closers, as shown in figures 26 to 35. This is easier and not nearly as wasteful as cutting an ordinary brick lengthwise in two.

King Closers are bricks cut so that one end is half the width of a brick. They are used in positions where the greater width at the back adds strength to the bond, as shown in figure 17. They usually occur at rebated openings in Flemish bond walls.



KING CLOSER

Fig 17.

Bond (that is, to bind) is the name given to any arrangement of bricks in which no vertical joint of one course is exactly over the one in the next course above or below it, and having the greatest possible amount of lap.

Footings.—These are the wide courses placed at the base of a wall to distribute the pressure over a greater area of ground. The course coming immediately upon the concrete should be twice the required width of the wall; thus, in a two-brick wall this course would be four bricks wide. Offsets of 2¼″ are then made on each side of each successive course till the desired thickness is obtained. Walls of two or more bricks in thickness should have bottom courses of footings doubled.

Care should be taken that the bricks in footings should be laid as far as possible as headers, but if stretchers are required in any course, they should be laid near the centre of the wall.

Figures 18 to 24 give sections of footings and walls in English bond from 1 to 3 bricks in thickness. Trenches are excavated for beds of concrete usually from 2 feet to 7 feet in depth, and 12 inches wider than base of footings (6 inches on each side). Section lines are omitted for the sake of clearness.

Seddon recommends that brick footings be dispensed with, and a deep bed of concrete substituted; and as the bed of concrete need not be wider than the width of footings, a saving is made over the ordinary method.

Bonds in Brickwork.—Bond in brickwork is the method of arranging each brick so that it laps over the sides of the bricks with which it is in contact above and below a distance equal to ¼ the length of the brick. To ensure good bond the following rules should be rigidly adhered to:—1st, the arrangement of the bricks must be uniform, and as few bats as possible be employed. 2ndly, a closer to be inserted after the quoin header in any course. 3rdly, the vertical joints in every other course to be perpendicularly in line on the internal as well as the external face. 4thly, stretchers are only to be used on the faces of the wall, the interior to consist of headers only.

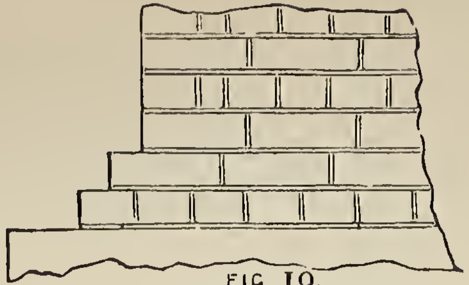


FIG. 19.
ELEVATION

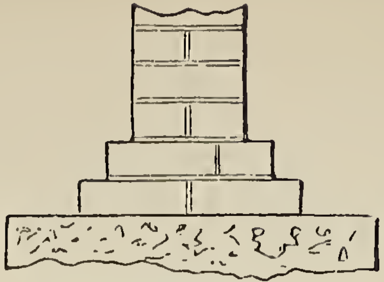


FIG. 18.
SECTION

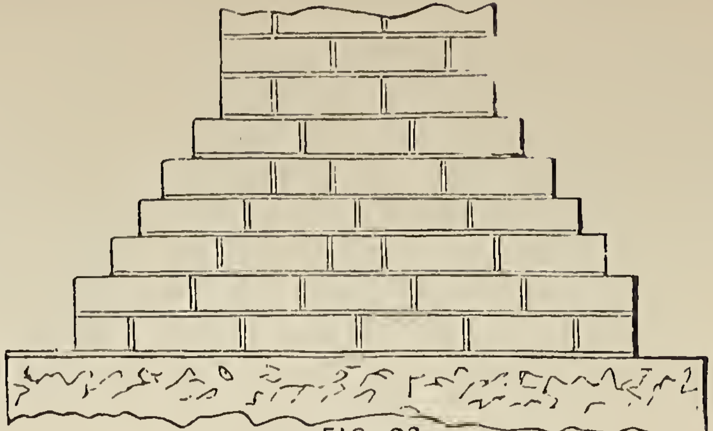


FIG. 23.
FOOTINGS FOR 2½ BRICK WALL

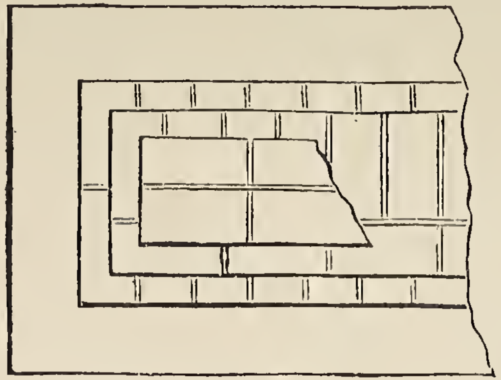


FIG. 20. PLAN

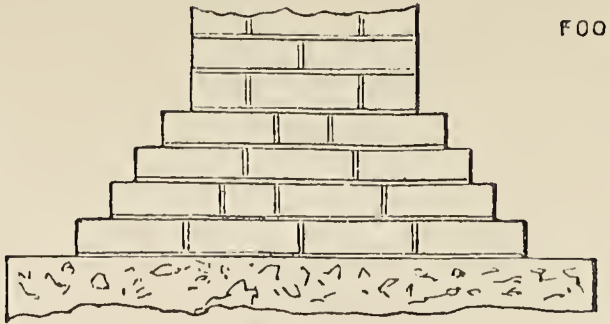


FIG. 22.

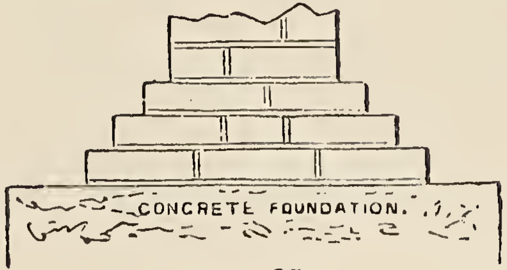


FIG. 21.

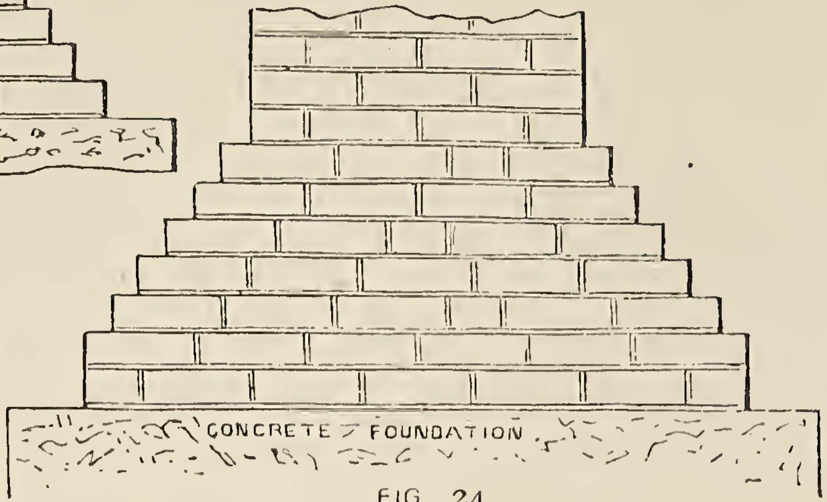


FIG. 24.

Hindrances to good bond often occur when facing bricks are used of different lengths and widths to the body of the wall; in 9″ walls where it is necessary to have two fair faces, very frequently facing headers are cut off, being an easy as well as a cheap method of overcoming the difficulty; but this weakens the wall to a large extent, and it would be better to bond in only every third or fourth course, as in garden-wall bond.

There are several kinds of bond used in brickwork. Those described in this chapter being as follows:—1st English, 2nd Double Flemish, 3rd Single Flemish, 4th English Cross, 5th Dutch, 6th Stretching or Chimney, 7th Heading Bond, 8th Sussex Bond, 9th Hoop Iron.

English Bond.—When the bond is arranged as shown in elevations and plans, figures 25 to 35, it is known as English bond, and sometimes old English bond. It consists of one course of headers and one course of stretchers alternately. In this bond bricks are laid as stretchers only on the boundaries of courses, thus showing on the face of the wall, and no attempt should be made to break the joints in a course running through from back to front of a wall. That course which consists of stretchers on the face is known as a stretching course, and all in course above or below it would be headers with the exception of the closer brick, which is always placed next to the quoin header to form the bond, and these courses would be called heading courses.

It may be noticed that in walls, the thickness of which is a multiple of a whole brick, the same course will show either—

(*a*) Stretchers in front elevation and stretchers in back elevation.
(*b*) Headers ,, ,, ,, headers ,, ,,

but in walls in which the thickness is an odd number of half bricks the same course will show either—

(*a*) Stretcher in front elevation and header in back elevation.
(*b*) Header ,, ,, ,, stretcher ,, ,,

English Bond.

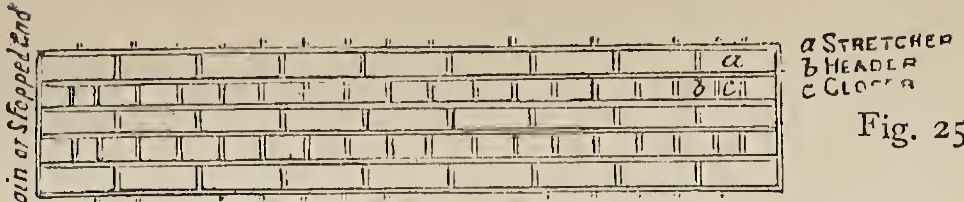


Fig. 25.

ELEVATION SHOWING ARRANGEMENT OF BRICKS IN FACE OF WALL.

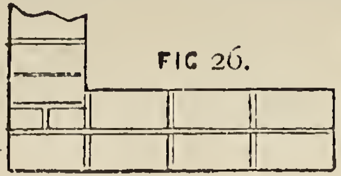


FIG 26.

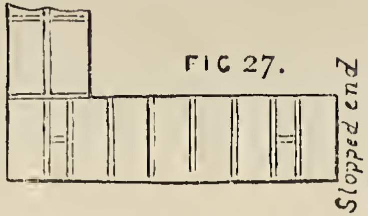


FIG 27.

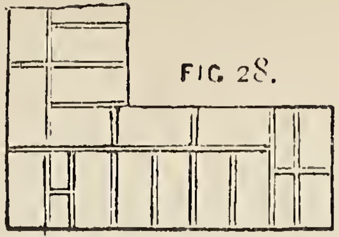


FIG 28.

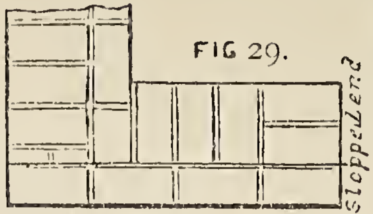


FIG 29.

PLANS OF ALTERNATE COURSES AT QUOINS 1½ BRICK WALL.

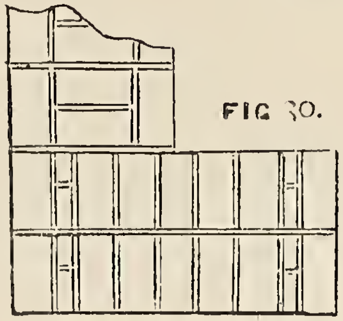


FIG 30.

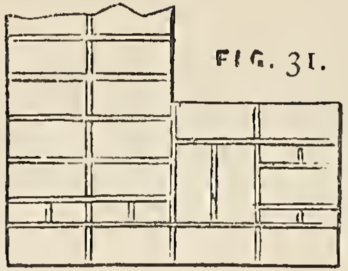


FIG. 31.

PLANS OF ALTERNATE COURSES AT QUOINS 2 BRICK WALL.

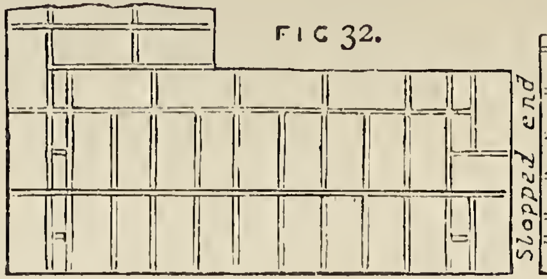


FIG 32.

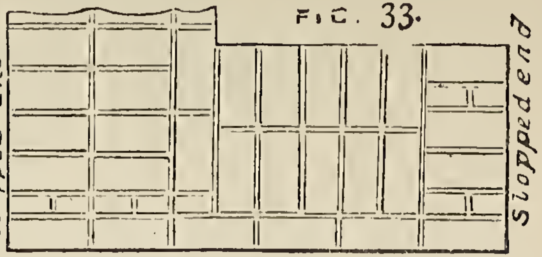


FIG. 33.

PLANS OF ALTERNATE COURSES AT QUOINS OF 2½ BRICK WALL.

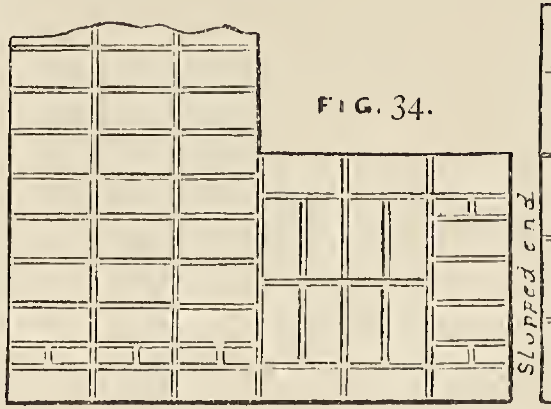


FIG. 34.

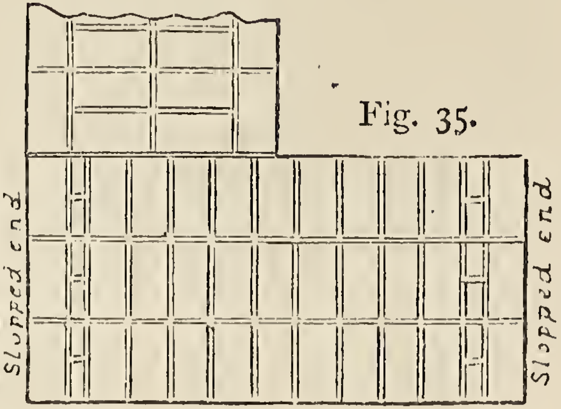
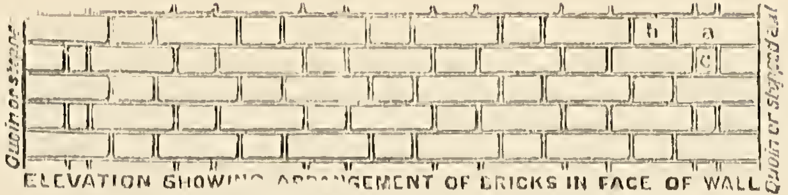


Fig. 35.

PLANS OF ALTERNATE COURSES AT QUOINS OF A 3 BRICK WALL.

Double Flemish Bond (Flemish Bond, both faces).



ELEVATION SHOWING ARRANGEMENT OF BRICKS IN FACE OF WALL

Fig. 36.

a. stretcher.
b header.

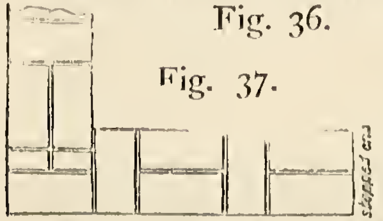


Fig. 37.

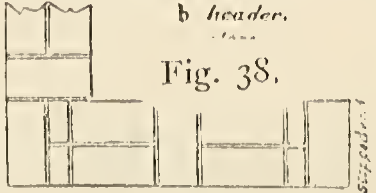


Fig. 38.

PLANS OF ALTERNATE COURSES AT QUOIN OF 1 BRICK WALL

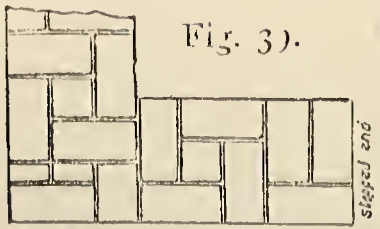


Fig. 39.

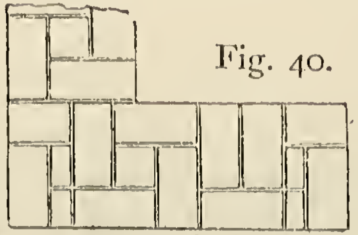


Fig. 40.

PLANS OF ALTERNATE COURSES AT QUOIN OF 1½ BRICK WALL.

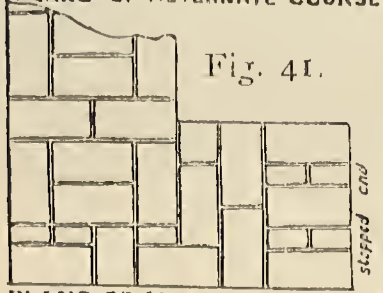


Fig. 41.

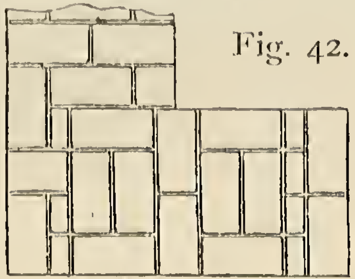


Fig. 42.

PLANS OF ALTERNATE COURSES AT QUOIN OF 2 BRICK WALL

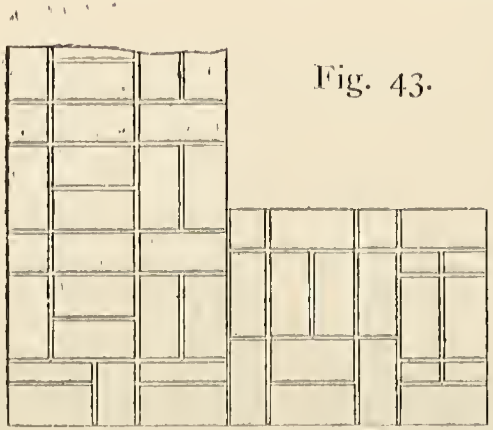


Fig. 43.

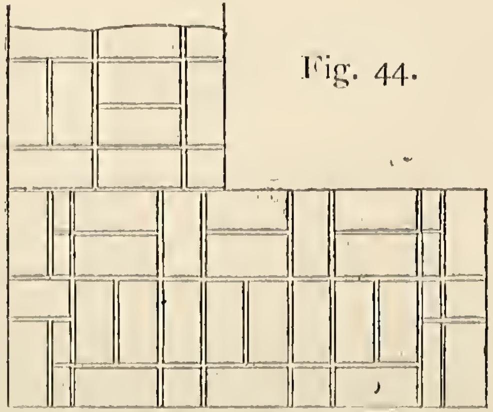


Fig. 44.

PLANS OF ALTERNATE COURSES AT QUOIN OF 2½ BRICK WALL.

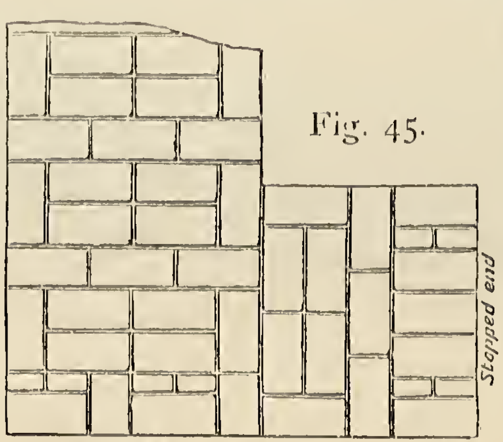


Fig. 45.

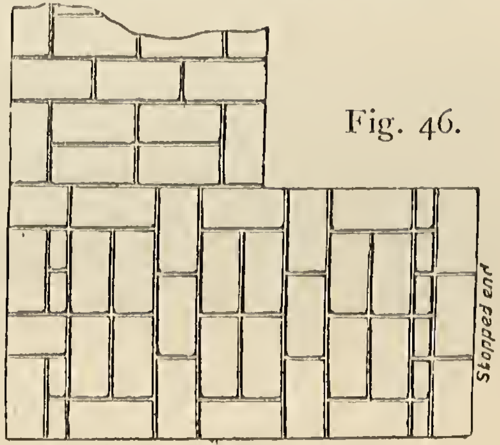


Fig. 46.

PLANS OF ALTERNATE COURSES AT QUOIN OF 3 BRICK WALL.

In setting out the plan of a course to any width, draw the quoin, or corner brick; then next to the face (which in front elevation shows headers) place closers to the required thickness of wall, after which set out all the front headers, and if the thickness is a multiple of a whole brick, set out headers in rear; if the thickness is an odd number of half bricks, set out stretchers in rear: the intervening space, if any, is always filled in with headers.

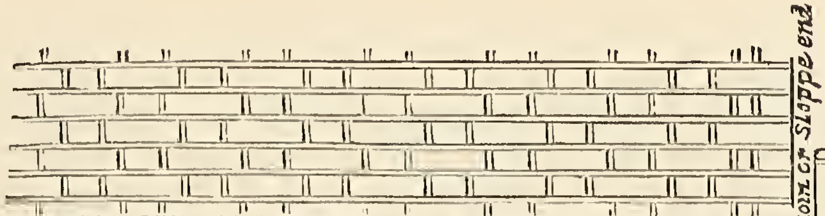
Double Flemish Bond has headers and stretchers alternately in the same course, both in front and back elevations, as shown in figures 36 to 46. It is weaker than English bond, owing to the greater number of bats and stretchers, but is considered by some to look better on the face. It is also economical, as it admits of a greater number of bats being used, so that any bricks broken in transit may be utilised. By using double Flemish bond for thin walls it is easier to obtain a fair face on both sides than with English bond.

Single Flemish Bond consists in arranging the bricks as Flemish bond on the face, and English bond as backing. This is done to gain as much strength as possible, and is generally used where more expensive bricks are specified for facing. The thinnest wall where this method can be introduced is 1½ bricks thick. Plans of alternate courses are given, figures 47 to 55. The front elevations are the same as in double Flemish bond.

English Cross Bond. — A class of English bond. Every other stretching course has a header placed next the quoin stretcher, and the heading course has closers placed in the usual manner.

Dutch Bond.—In every alternate stretching course a header is introduced as the second brick from the quoin, three-quarter bricks are used in the stretching courses

Single Flemish Bond (English Bond backing).



ELEVATION SHOWING ARRANGEMENT OF BRICKS IN FACE OF WALL.

Fig. 47.

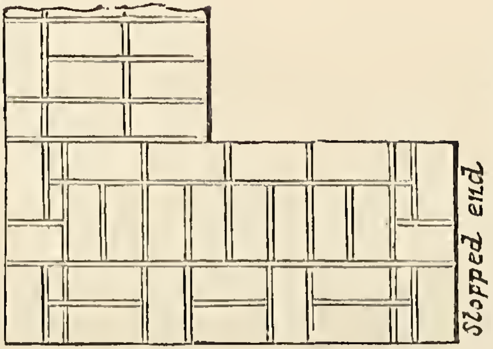


Fig. 52.

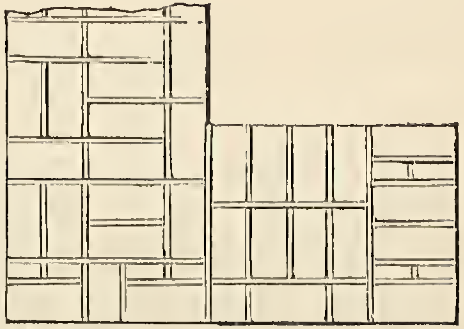


Fig. 53.

PLANS OF ALTERNATE COURSES AT QUOIN OF 2½ BRICK WALL.

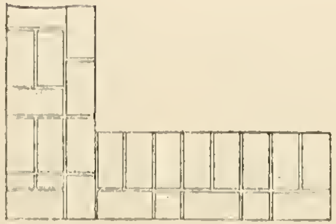


Fig. 48.

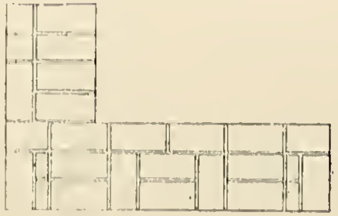


Fig. 49.

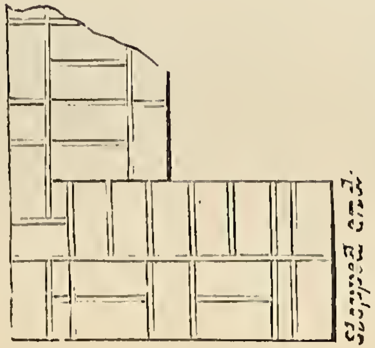


Fig. 50.

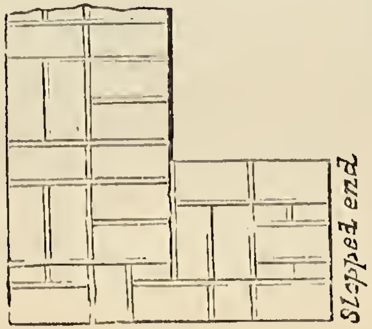


Fig. 51.

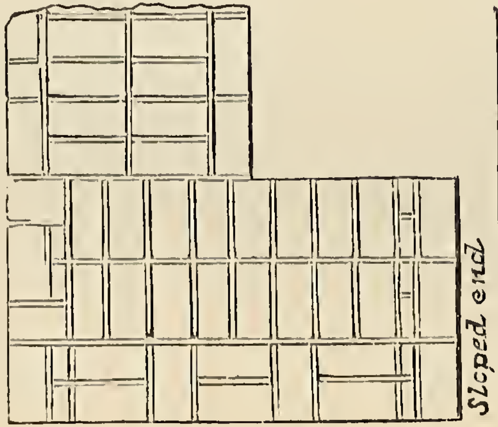


Fig. 54.

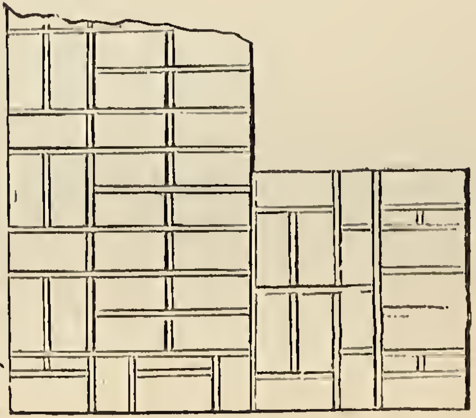
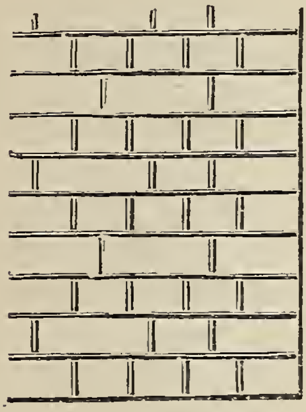


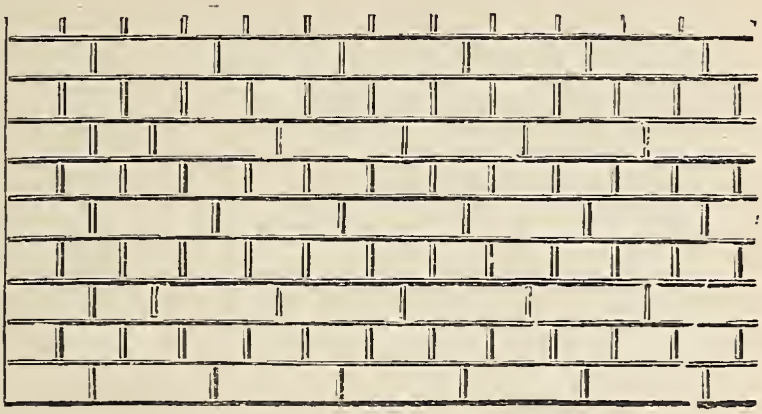
Fig. 55.

at the quoins, and the closers are dispensed with in the heading courses, as shown in figures 56 to 61; the longitudinal tie becomes much greater, and the appearance of the elevation is certainly superior to much of the very inferior work one is accustomed to see as examples



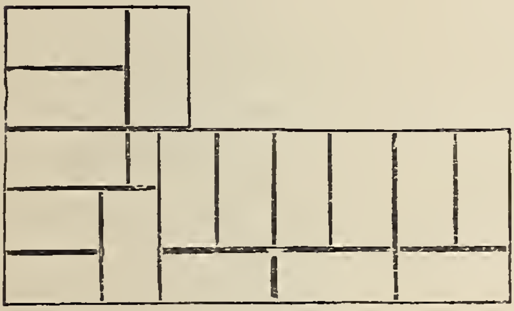
ELEVATION ON RETURN.

Fig. 56.



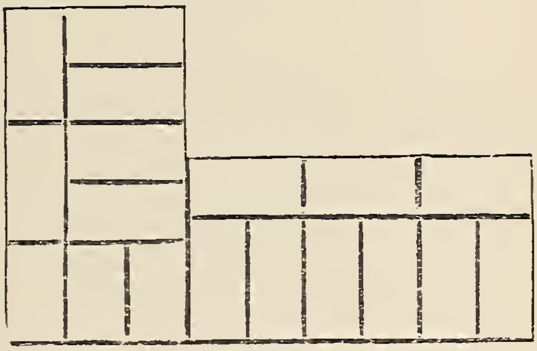
ELEVATION SHOWING ARRANGEMENT.

Fig. 57.



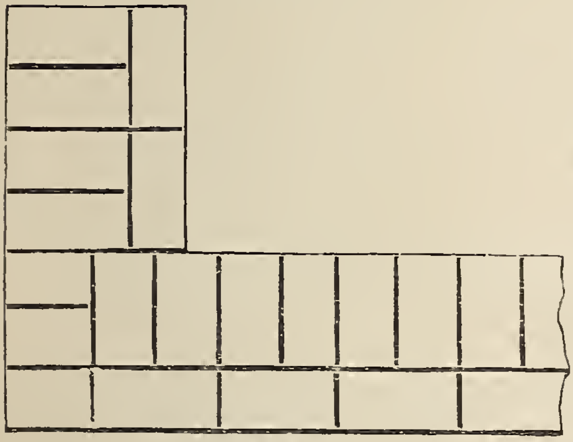
COURSE.3.

Fig. 58.



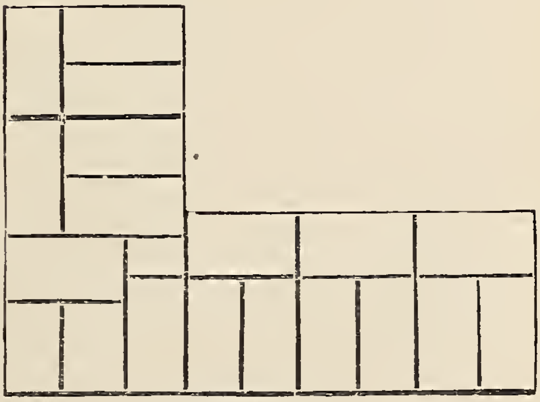
COURSE 4.

Fig. 59.



COURSE.1.

Fig. 60.



COURSE.2.

Fig. 61.

of the modern bricklayer's skill in bonding. Should there be a fracture, it is supposed to throw it more obliquely.

Stretching or Chimney Bond should be used only for walls half brick thick, as for partition walls. All bricks are laid as stretchers upon the face.

Heading Bond.—All bricks show as headers on face. Used chiefly for rounding curves, and has but little longitudinal strength.

Sussex Bond, Scotch Bond, garden or boundary wall bond, are the names given to walls built with three stretchers and one header in same course, constantly recurring, as shown in elevation, figure 62. This method is used for walls one brick thick that are seen on both sides, as it is easier to obtain the two fair faces by using stretchers than headers, the length of which usually vary.

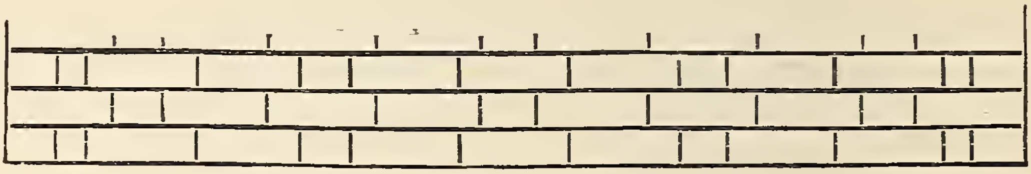


Fig. 62.

Hoop Iron Bond.—An additional longitudinal tie is often inserted in walls, called "*hoop iron bond*," usually pieces of hoop iron 1″ by $\frac{1}{16}$″, one row for every half brick in the thickness of the wall. It should be carefully tarred to prevent oxidation, and sanded or galvanized before using. It is hooked at all angles and junctions. If bedded in two courses in cement, additional strength is gained; pieces of hoop iron may be used with advantage when the bond at any part of a wall is defective.

Bond Timbers.—It is now generally acknowledged that timbers should not be built in walls to tie or bond them in

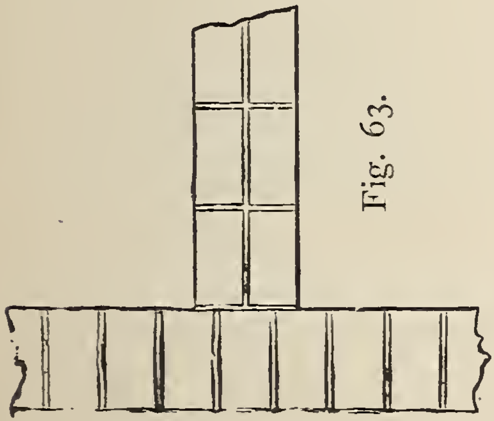


Fig. 63.

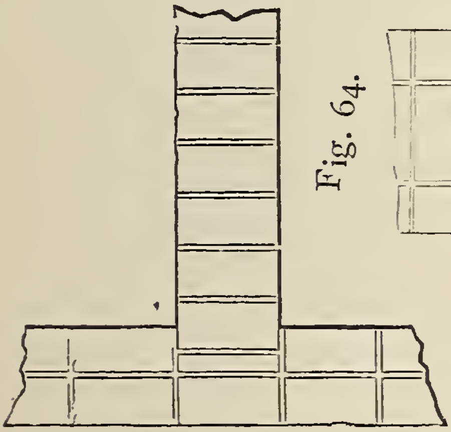


Fig. 64.

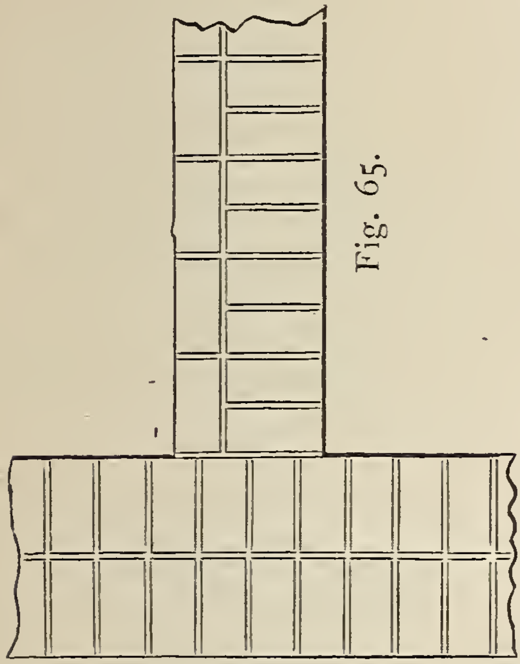


Fig. 65.

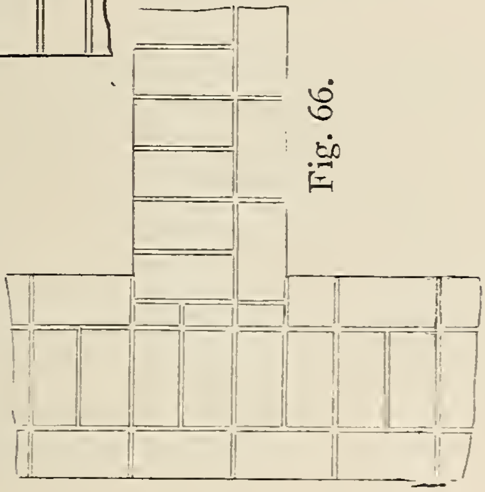


Fig. 66.

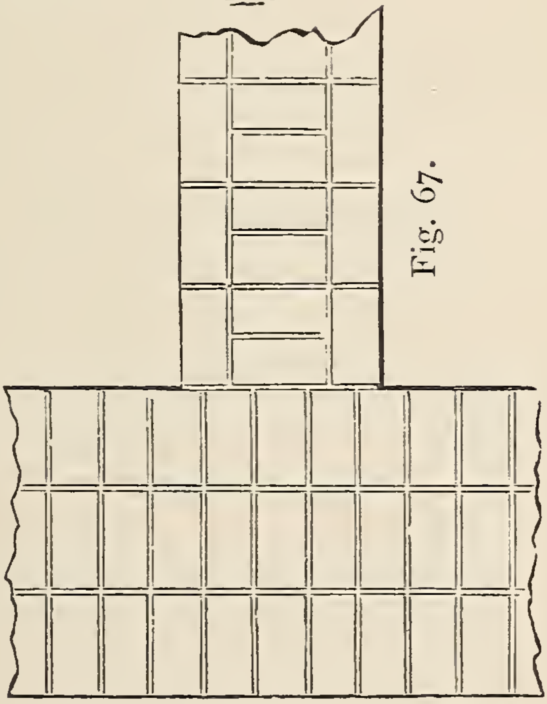


Fig. 67.

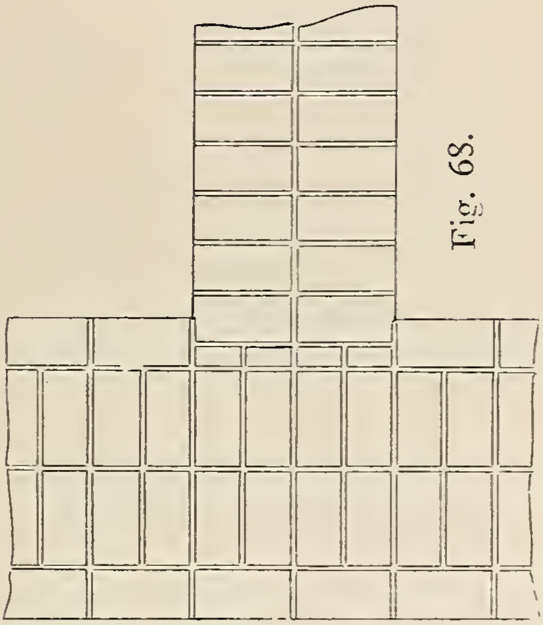


Fig. 68.

their length. They are superseded by hoop iron bond for the following reasons:—Bond timbers are liable to shrink and become loose, and in time, owing to the absence of a free circulation of air, are subject to the dry rot and perish; they are also liable to be attacked by fire, and, at a critical moment, the walls at that section are practically reduced in thickness by the width of the timber.

Wall Plates are plates fixed in or against walls to receive the ends of joists or rafters. They should not be built in walls for the same reasons as bond timbers.

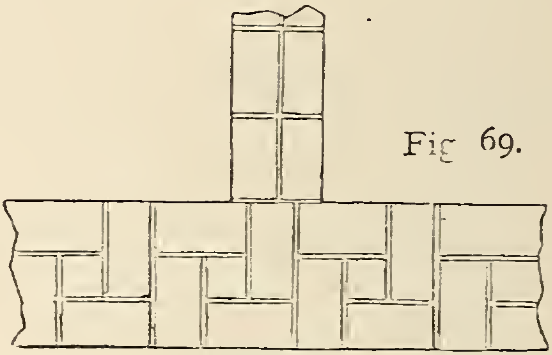


Fig 69.

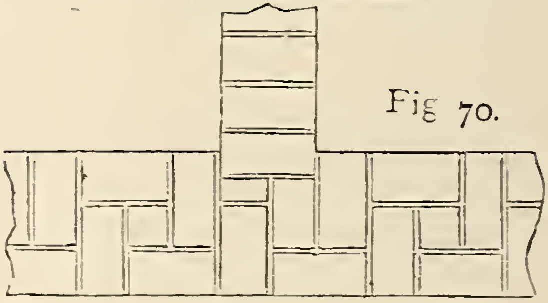


Fig 70.

Junctions of Cross Walls.—The bond is obtained in cross or party walls abutting against main walls by placing a closer 4½″ from the face in every alternate course in the main wall, thus leaving a space 2¼″ deep and of a length equal to the thickness of the cross wall for the reception of the 2¼″ projection in every other course of the cross wall, as shown in figures 63 to 68.

Figures 69 and 70 illustrate the junction of 1½ brick Flemish bond with 1 brick English bond.

Copings are constructed in brickwork set in cement to form waterproof tops, and prevent water getting into the interior of wall. Two sections are shown in figures 71 and 72.

Corbelling.—When a projection has to be carried, as in the case of a chimney breast, without taking supports from the footings, the method of corbelling sometimes resorted to consists of $1\frac{1}{8}''$ offsets, to the required projection. Figure 73 shows this method applied to carrying wall plates, but this arrangement is not to be recommended, as a sudden blow is likely to fracture the bricks which are unsuitable to act as cantilevers.

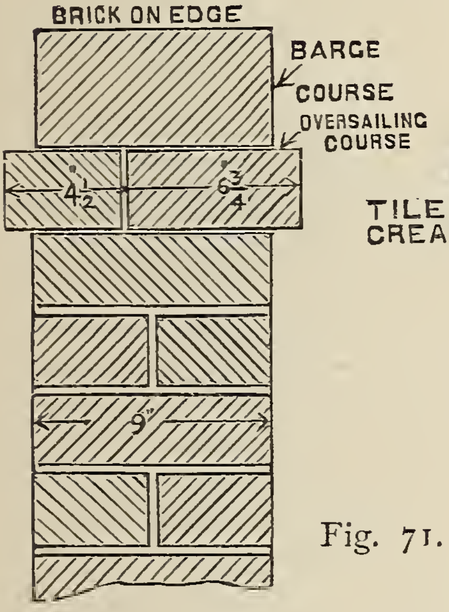


Fig. 71.

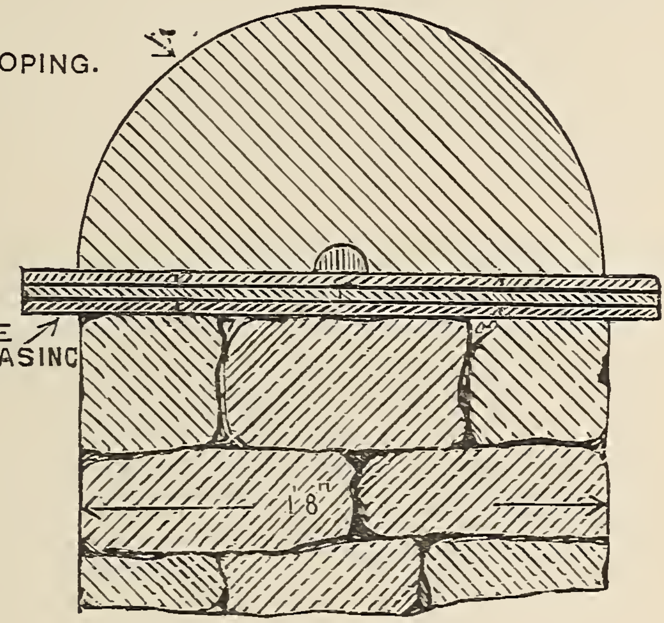


Fig. 72.

String Course is the name given to a horizontal projecting course, carried along the face of wall, anywhere between plinth and cornice, as in figure 73, to give a pleasing effect.

Plinth. — A horizontal and usually projecting course built at base of wall, as in figure 74, to protect the wall from injury, and give additional strength.

Reveals are the vertical sides of window or door openings between the face of wall and window or door frames. The horizontal distance between is the clear span of opening.

Jambs are the vertical sides of an opening, and are often parts of rebates, as in window opening, figure 75. They are usually covered with plaster or wood linings.

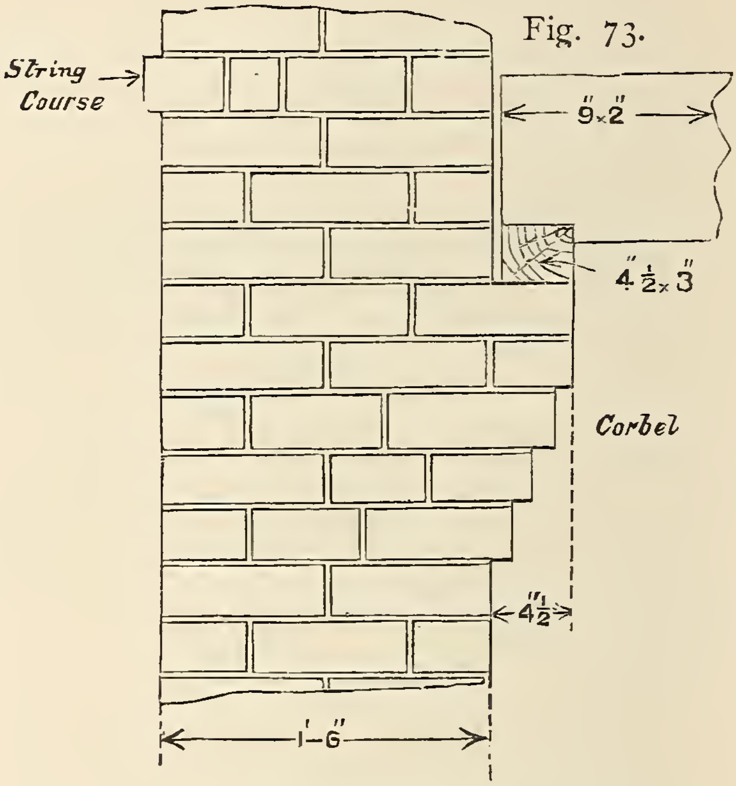


Fig. 73.

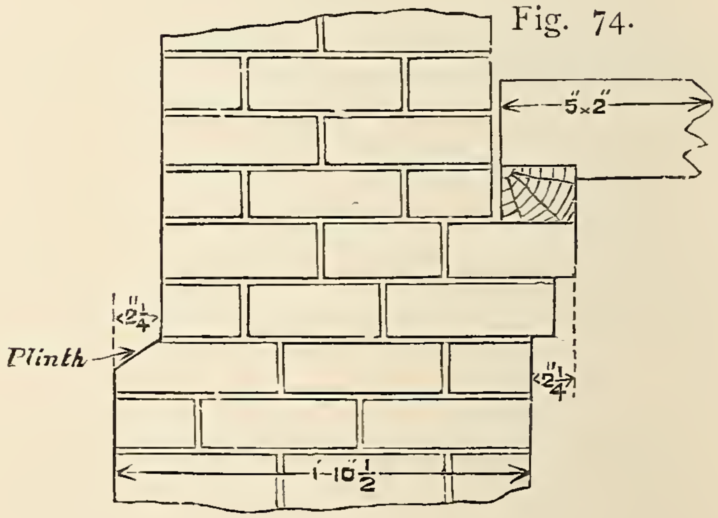


Fig. 74.

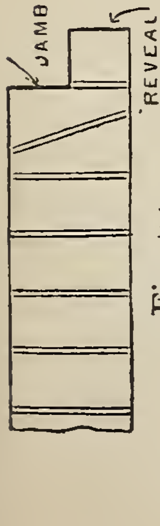


Fig. 75.

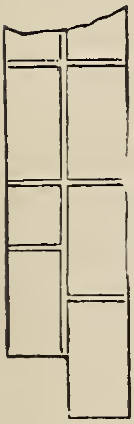


Fig. 76.

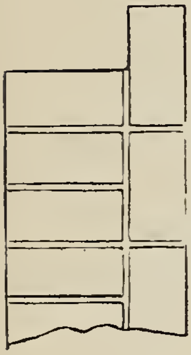


Fig. 77.

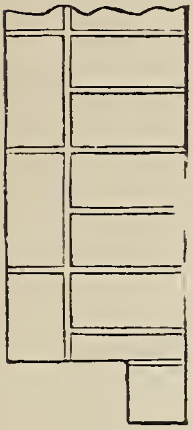


Fig. 78.

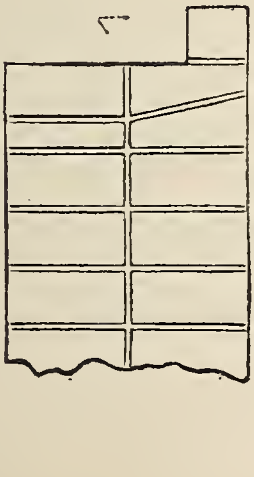


Fig. 79.

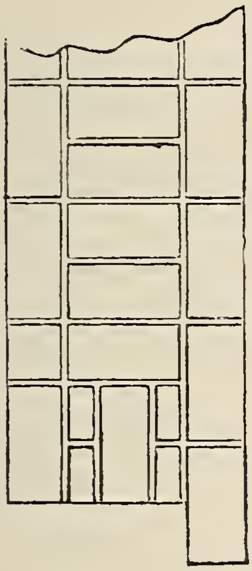


Fig. 80.

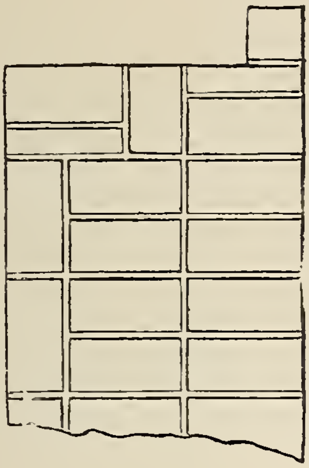


Fig. 81

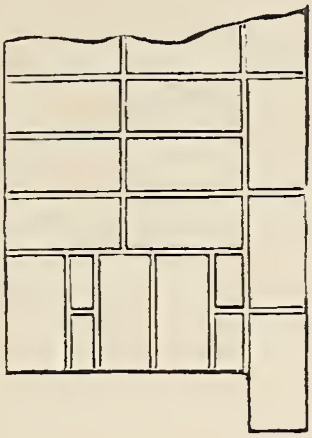


Fig. 82.

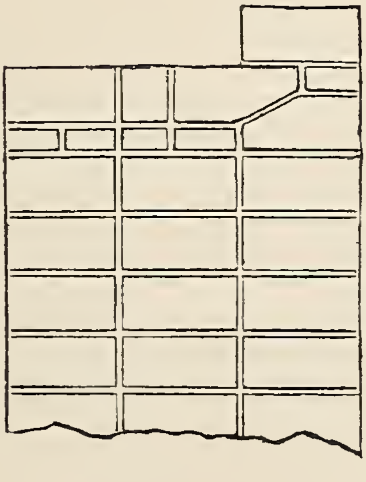


Fig. 83.

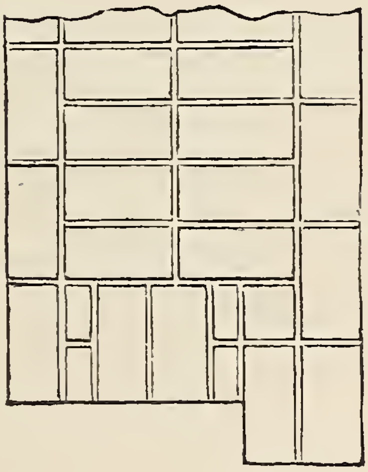


Fig. 84.

Figures 75 to 84 show brick reveals, with rebated jambs in English bond.

Piers.—Piers in brickwork are square pillars constructed to support heavy weights transmitted to them by beams and girders, or to receive the thrust of two or more arches, the resultant of the thrusts of which falls in a vertical line.

Fig. 87.

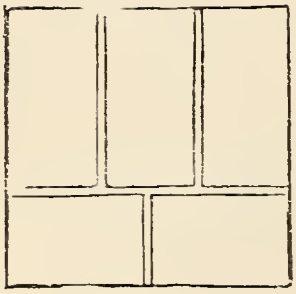


Fig. 85.

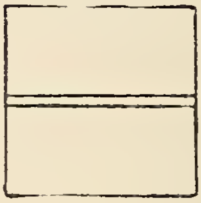


Fig. 90.

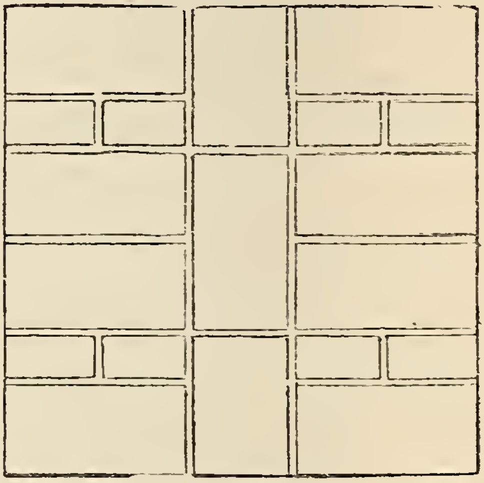


Fig. 86.

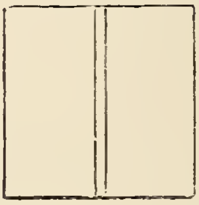


Fig. 88.

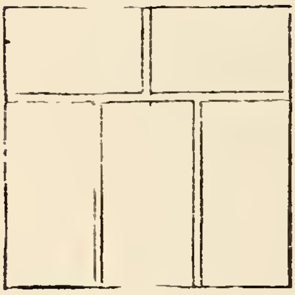


Fig. 91.

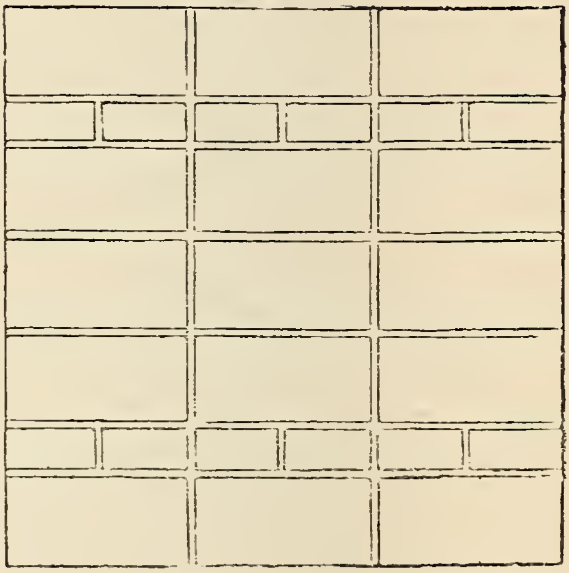
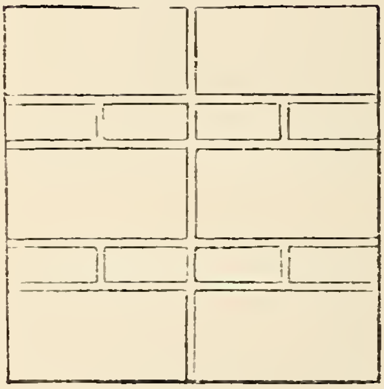


Fig. 89.



Figures 85 to 91 show plans of piers built in English bond, one to three bricks square. It is necessary to draw the plan of only *one* course, as the adjoining courses have the same arrangement of bricks, but placed in such a manner that those in the front elevation of one course are in the side elevation of the next, above or below.

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BUILDING CONSTRUCTION AND DRAWING.

Figures 92 to 95 show plans of piers built in double Flemish bond one to three bricks square.

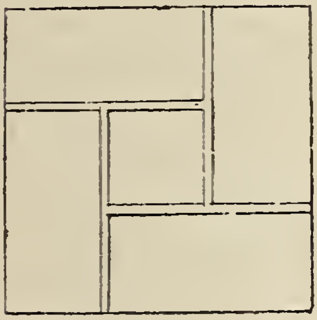


Fig. 92.

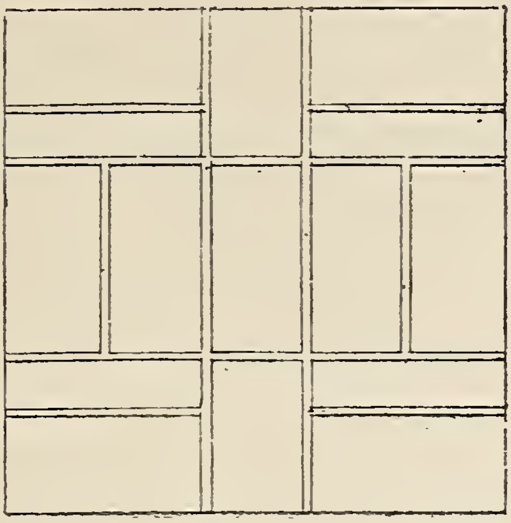


Fig. 94.

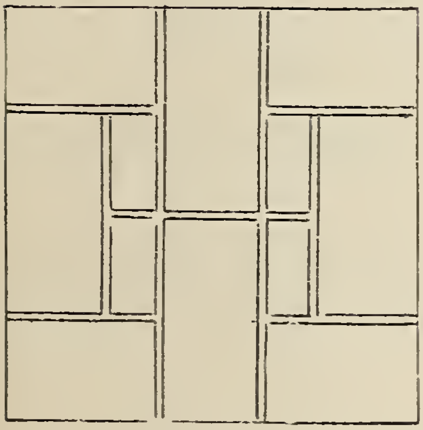


Fig. 93.

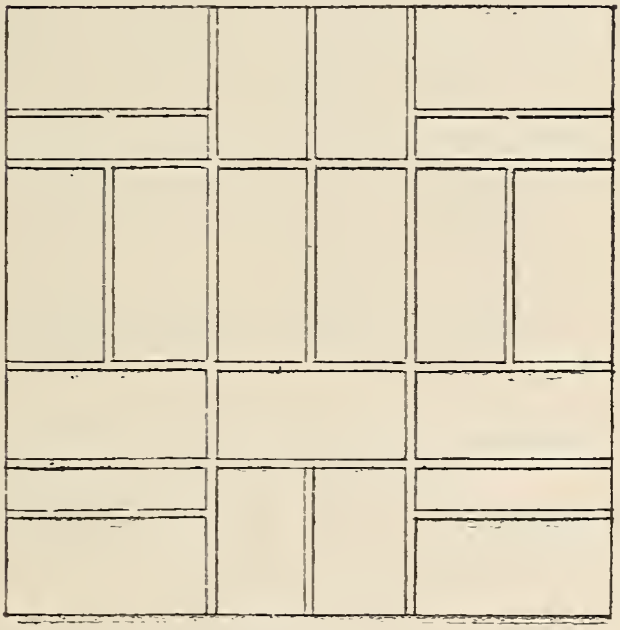


Fig. 95.

Abutments.—Abutments are piers designed to receive the inclined thrust from one or more arches; they are therefore made of a greater weight than ordinary piers by increasing the height or by increasing the width in the direction of the thrust.

Arches.—An arch is an arrangement of wedge-shaped blocks built about the form of some curve, mutually supporting each other, and being supported at both ends by abutments or piers. They are designed to support the weight of a wall over an opening made in the same. The important points to be observed in the construction of an arch are as follows :—

1st. Sufficient support and strength in the abutments to prevent the arch deflecting when loaded, acting with a leverage and overturning them.

2ndly. Strength enough in the arch to prevent the weight above crippling it.

3rdly. Sufficient area in the pier and arch to prevent failure by crushing.

4thly. All bed joints should be perpendicular to the line of least resistance. (See Article, Part 2.)

The names by which arches are known is generally that of the curve of which the arch is a segment.

The following are the technical terms used in connection with the arch :—

Voussoirs are the courses of bricks or stones which compose the arch.

Springers are the extreme or lowest voussoirs of arches.

Skewbacks are the bricks forming the sloping abutments on which the extreme or lowest voussoirs rest, of flat or segmental arches.

Key is the uppermost or central brick or stone of the arch.

Intrados or soffit is the under or concave side of the arch.

Extrados or back is the upper or convex side.

Abutments are the outside supports.

The supports between two arches are called piers.

Impost.—The upper part of a pier or abutment where an arch rests or springs from, generally finished with a moulded cap, as shown in figure 96.

Springing Points.—The starting points where the curves of the arch commence, as seen in elevation.

Span is the horizontal distance between springing points.

Crown is the highest point of extrados of arch.

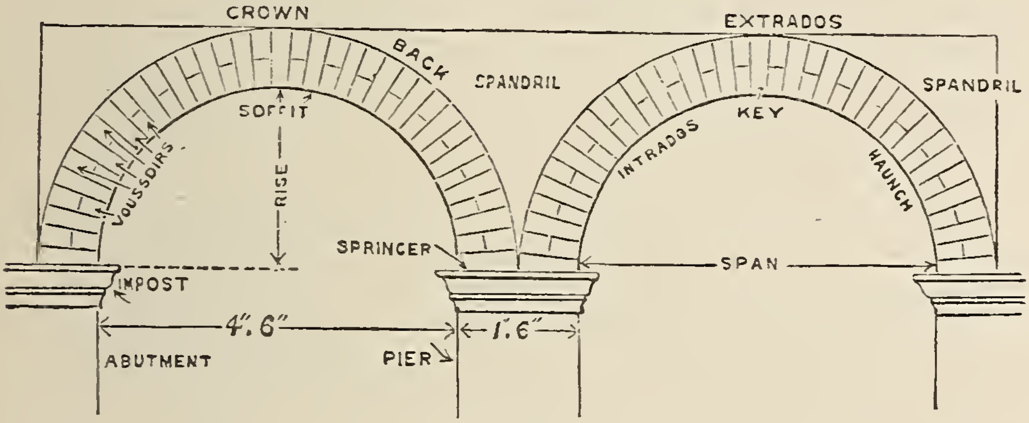


Fig. 96.

Rise is the vertical distance between the highest point of the soffit and the level of the imposts or springing points.

Haunch is the name given to lower half of the arch, from the springer or skewback, midway to the crown.

Spandril.—The irregular triangular space between two arches, or the space enclosed by vertical lines drawn from the springing of the extrados and the horizontal line tangent to the crown.

Ring Courses of Arches.—The name given to those courses of brickwork that partake of the circular form, as seen on face of the wall.

String Courses of Arches are the longitudinal courses as seen on the soffit of the arch.

Lacing Courses.—Ring courses of arches are broken by a bonding or lacing course, as shown in figure 97. These lacing courses prevent the entire weight being carried by any one ring course.

Arches may be either gauged, rough axed, or plain brick arches.

Gauged Arches are used for external faces of walls, and consist of bricks cut and rubbed to form a fine joint, and bedded in lime putty, so that the joints are only $\frac{1}{32}$ inch thick. This is considered by some the best work, and is the most expensive. Four illustrations of gauged arches are given, see figures 98 to 103.

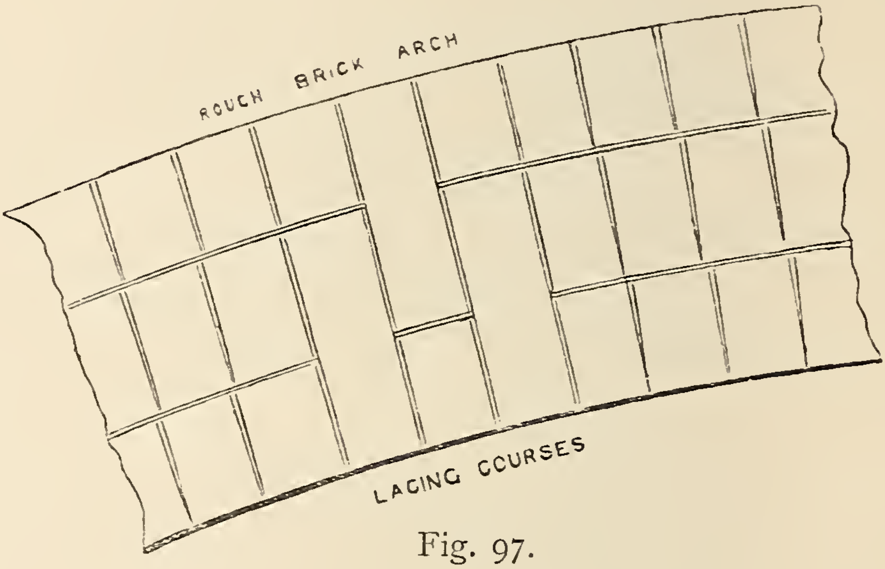


Fig. 97.

Flat or straight gauged arches are cambered to allow for settlement of wall, and should be sufficient that after settlement has taken place, the soffit line of arch never appears to sag or drop.

Rough Relieving or Discharging Arches are usually formed by laying ordinary bricks on edge (without being cut or rubbed), on rough centres, or turning-pieces, or on a brick core shaped to the required curve, as in figure 104, or on a curved wood lintel, illustrated in figure 105. It will be seen that the joint will be much wider on the extrados than on the intrados, as all the joints will be V-shaped in elevation. If arches of this description were built in 9-inch rings this defect would be serious; consequently these arches should be constructed in 4½ inch rings, as shown in figure 104, which to a great measure reduces the imperfection.

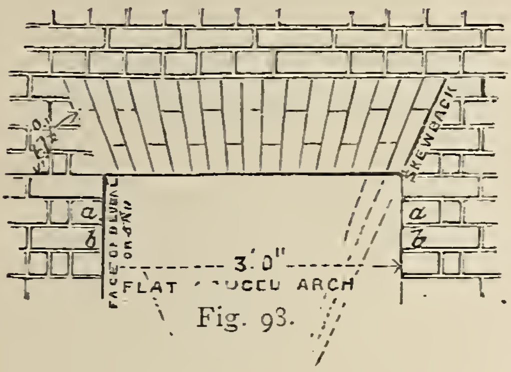


Fig. 98.

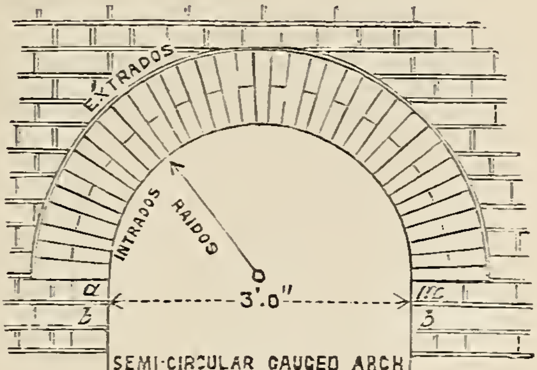


Fig. 101.

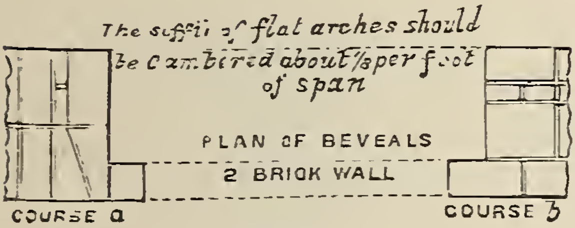

The soffit of flat arches should be cambered about ⅛ per foot of span
PLAN OF BEVEALS
2 BRICK WALL
COURSE a
COURSE b

Fig. 99.

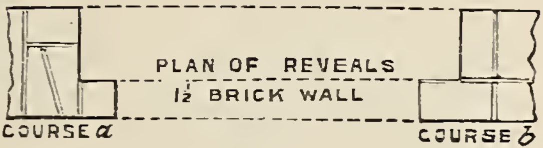
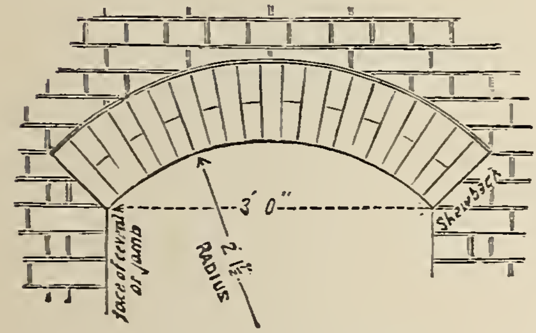


Fig. 102.



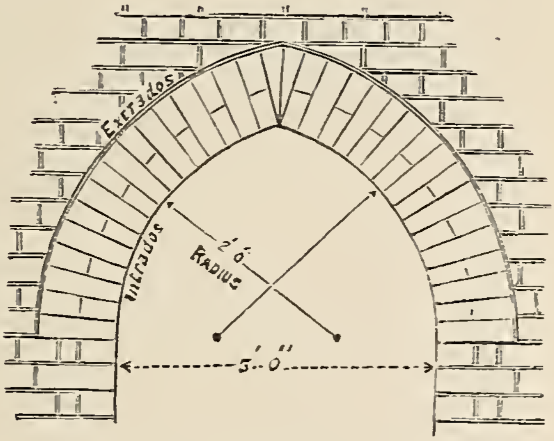


Fig. 100.—Segmental Gauged Arch. Fig. 103.—Pointed or Gothic Arch.

This method is used chiefly for internal arches to distribute the weight over openings on to the piers or abutments, or to distribute the pressure carried by piers over a greater area, as in the case of inverted arches, as illustrated in figures 106 and 107.

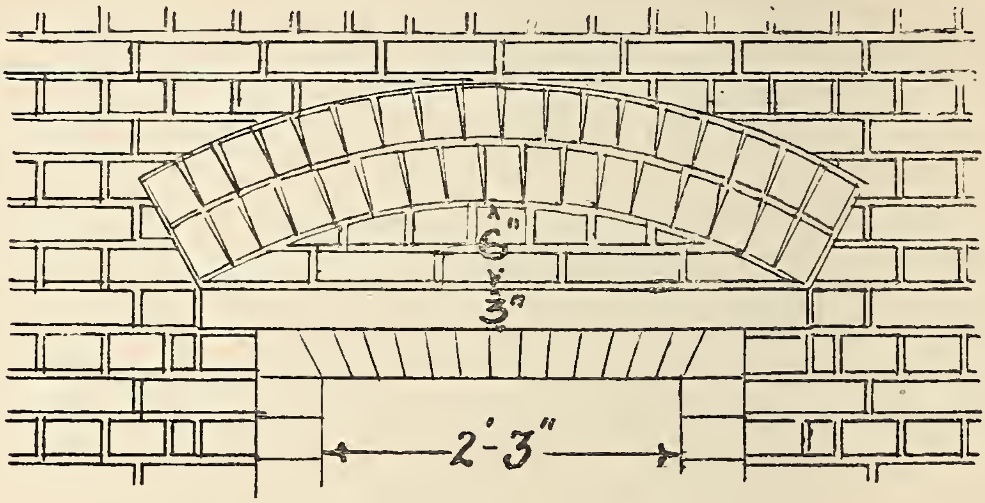


Fig. 104.

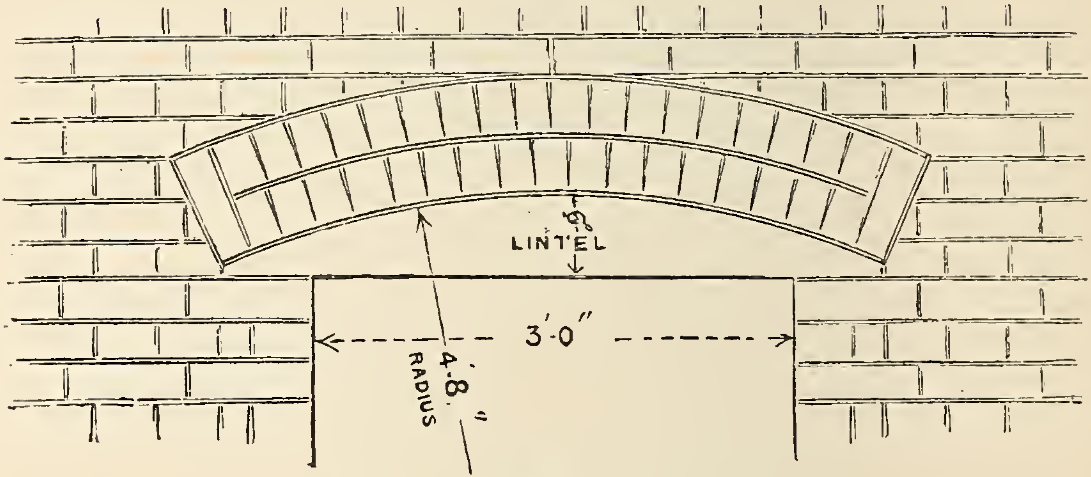


Fig. 105.

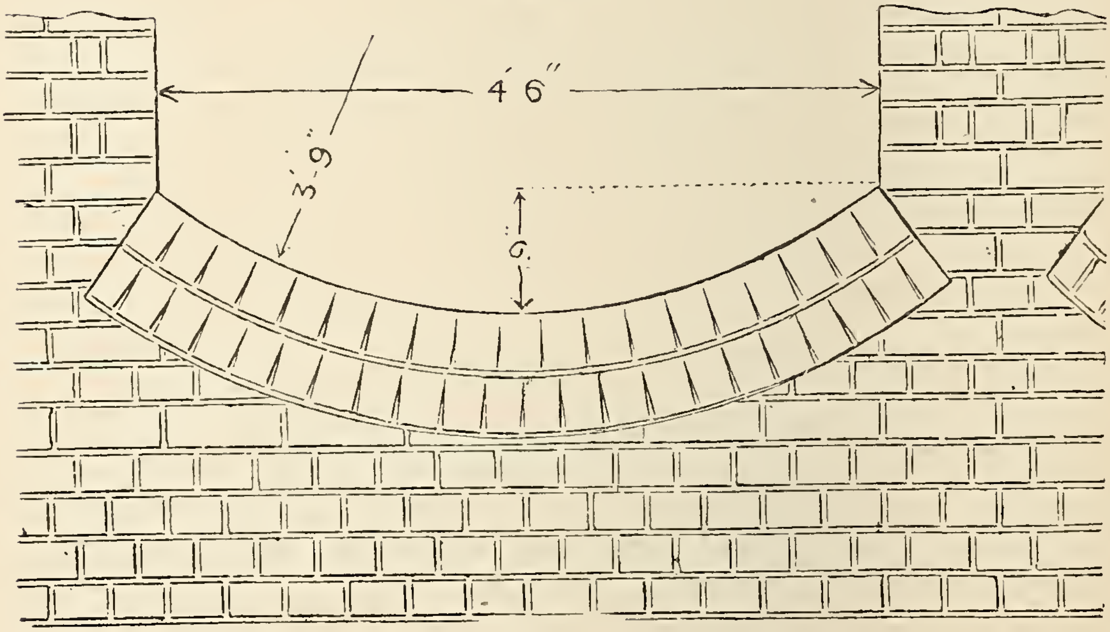
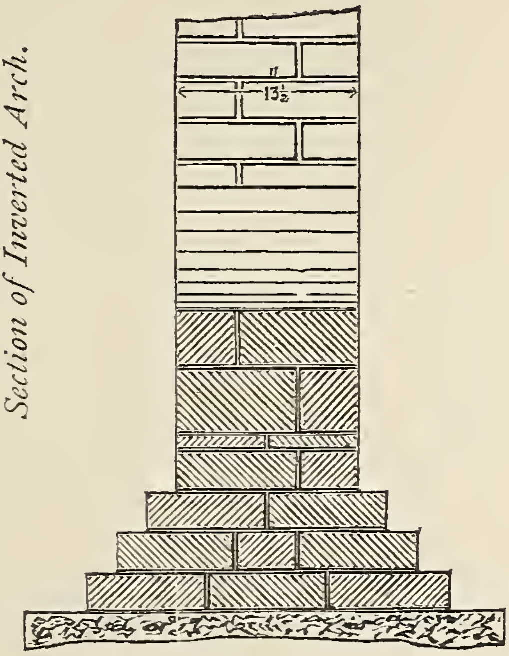


Fig. 106.

Figure 108 shows another rough brick arch, which is known as the French or Dutch arch, and is often used for external arches that are to be plastered over to avoid the expense of a flat gauged arch. It is only used in rough work, and is of weak construction.



Section of Inverted Arch.

Fig. 107.

Trimmer Arches.—These are a form of rough arch adopted for supporting hearths in front of chimney breasts, and having an abutment against the trimmer or trimming joists, as shown in figure 227.

Rough Axed Arches.—These arches are employed where it is required to have a strong arch of a neat appearance for the elevations of factories or warehouses, etc. The voussoirs are of the ordinary well-burnt facing brick, and are neatly cut with the bricklayer's axe to the required shape.

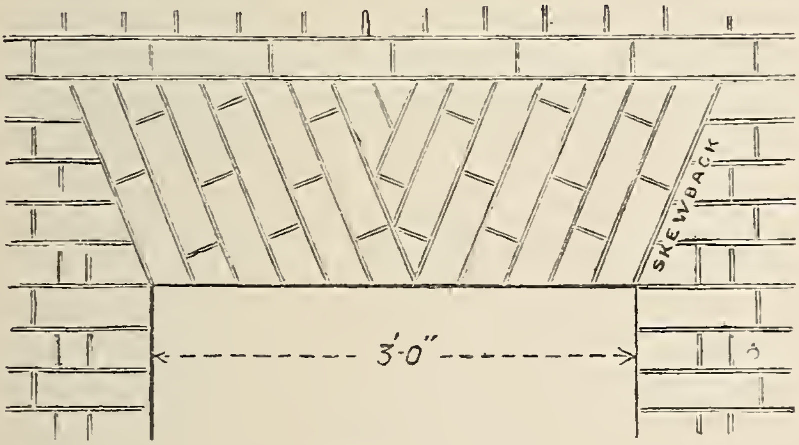


Fig. 108.

The roughly cut surface forms a good key for the mortar and resists the sliding tendency of the voussoirs. The joints are about $\frac{3}{16}$ths of an inch.

Gauged Arches.—These are used for the external faces of walls. They consist of soft bricks of a fine texture. They are cut and rubbed on a stone to the required shape of the side joints, having sharp arrises, to form a fine joint, which when finished should not be more than $\frac{1}{32}$ of an inch thick. The voussoirs are jointed in lime putty to about $\frac{1}{2}''$ from the face, the back portion being scored out and grouted in portland cement.

The depth of flat arches varies to some multiple of the thickness of a brick, being rarely less than 9″.

In flat-gauged arches there is a camber of $\frac{1}{8}$ of an inch for every foot of span, to compensate for any settlement, and to prevent the appearance of sagging common to all horizontal lines. To obtain the centre from which the bed-joints are struck, the following rule is adopted:—Set out the top and bottom boundary of the arch, assuming it to be 1 foot in depth, and then mark off on each extremity of the extrados $1\frac{1}{2}$ inches for every foot in the clear span of the arch beyond the extremities of the intrados; by joining these points by a line the inclination of the skewbacks is obtained, and if the line be produced, the intersection gives the centre of the arch. The true depth of the arch may then be set out. All gauged arches should have an odd number of bricks in order to have a key, and to make the joints of the voussoirs symmetrical about the line.

Arch Built with Orders.—This is another treatment of the arch where employed in the openings of very thick walls where the arch consists of a number of rings similar to a rough arch. It is a common practice to diminish the width of each ring from the outer, which is generally in width the full thickness of the wall to the inner ring, the width of which is very much smaller, thus forming a number of receding planes: each of these rectangular rims is termed an order. This relieves the opening of the clumsy and heavy appearance that is attendant upon a square opening in such a position; it also admits of the distribution of light inside to a much greater extent than in the case with a square opening. The jambs inside such an opening are usually splayed; the inner edge of the splay may be carried round the outer arch in a concentric curve or curves, or the inner arch may be an ordinary barrel arch, with its crown at or near the same height as that of the outer, and with the springing-line much lower, thus forming a curved line of intersection on the internal jambs and soffit. The edges of the external receding planes are often richly moulded. The orders may rest at the springing of the arch on the abaci of some small collonettes, or they may be continued to the sill, as shown in figures 109 to 111.

Lintels.—These are horizontal members placed over square openings to form the head and support the work above; they may be of wood, iron, coke-breeze concrete, or stone.

Wood Lintels consist in brickwork of pieces of timber from 4½ by 3 inches upwards, according to the span of the opening; they are generally assisted by a rough arch as a precautionary measure in the event of the timber being destroyed. The space between the lintel and the arch is filled with a brick core, see figure 104. The lintel sometimes has its upper surface curved, thus forming a turning piece for the arch, see figure 105.

Iron Girders are generally used where the openings are very wide, and where there is no room for an arch above.

Coke-breeze Concrete is often employed, as it is, to a certain extent, fire-resisting, and will admit of joinery being fixed to it, as it will hold nails and screws with great tenacity. These lintels are often curved on their upper edge, in which case they are relieved by an arch above, or they are made straight on their upper surface and their depth is increased.

Stone Lintels are made straight on their upper surface, and either directly support the weight above, or they are assisted by a relieving arch above. These are usually employed in brickwork on the external surface.

Fixing Joinery to Brickwork.—The following materials are generally built in or secured to brickwork to assist in the fixing of joinery thereto :—

Breeze Bricks, into which nails and screws may be driven,

Fig. 109.

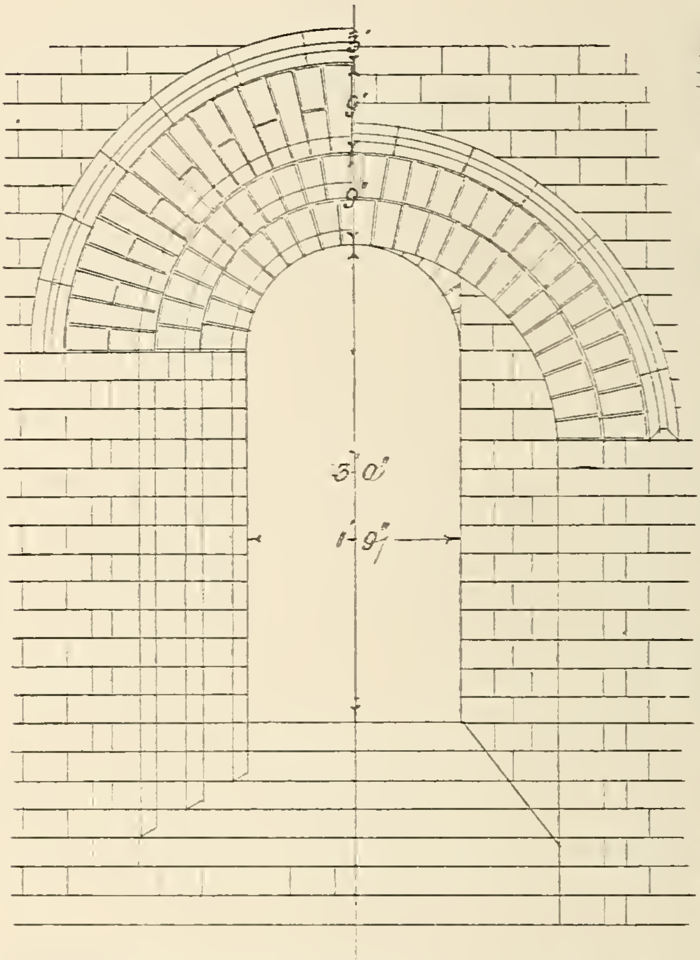
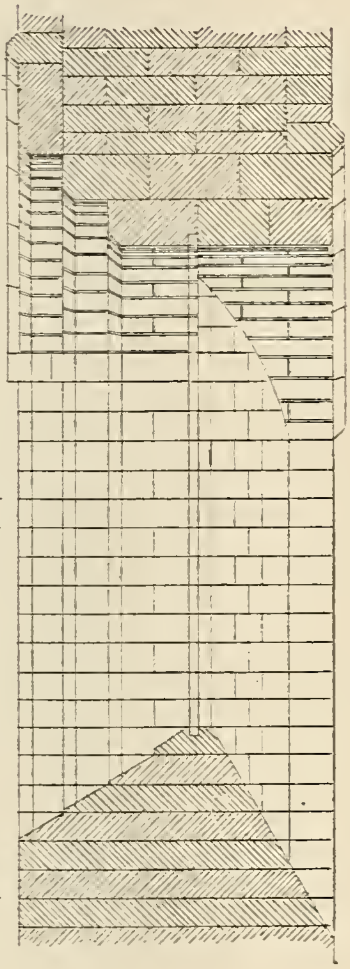


Fig. 110.



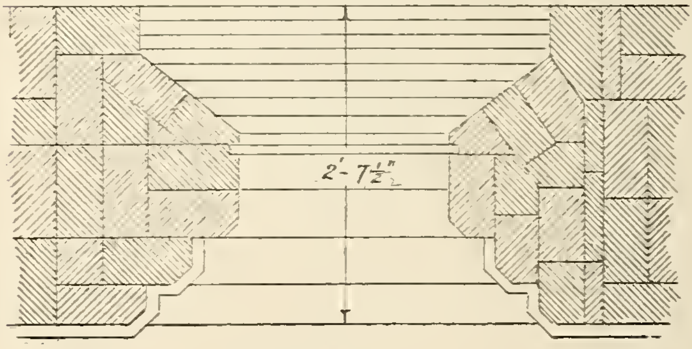


Fig. 111.

together with other kinds of fixing. Breeze bricks are preferred to wood in any form, owing to their not shrinking and not perishing to the same extent as wood; these are made a similar thickness and width as ordinary bricks, and can be built in the walls in a similar manner.

Wood Bricks, of same dimensions as ordinary bricks, have been used to form fixing surface in brickwork, as shown in figure 418, but they are objectionable, because they shrink, and become loose or are liable to rot.

Wood Plugs are wedges cut on the twist; they are usually driven between the joints of brickwork to obtain a fixing for joiners' work, as shown in figure 418, but are not to be recommended, as they sometimes damage the wall.

Wood Joints are lengths of wood, 4½ inches by ⅜ inch, built into walls at intervals, or wherever fixing is required, as shown in figure 418. The wood practically does not shrink in thickness; it is the best mode of fixing in most situations, but has to be inserted while the brickwork is being carried up.

CHAPTER III.

MASONRY.

Definition.—Masonry is the art of building in stone in a similar manner to that of brick, with the exception that brickwork is carried out with uniform-sized blocks, thus admitting of a number of definite systems of laying the bricks, whereas in stone, the pieces of material are in the great majority of cases of varying dimensions, thereby making it a matter of great skill to obtain a proper bond in the work, and owing to the irregular shape of the material the walls have to be made considerably thicker than walls of the same height in brick.

Technical Terms.—The following is a list and also an explanation of the labours in stonework :—

Bond, Lap and Course have the same meaning as given under brickwork.

Through or thorough stones are those which are laid across the entire thickness of wall, to tie or bond it, but are considered objectionable for the reason that if any projection has to be taken off at the back, to present a fair face, it would disturb the setting of the adjoining masonry, and damp is more likely to show on the interior of walls where the continuity of the material is uninterrupted.

Headers.—The name applied to stones, the lengths of which are $\frac{2}{3}$ to $\frac{3}{4}$ thickness of wall, and are laid across it.

Bonders may be either "throughs" or "headers."

Grout is a thin mortar, which is poured over the stones when brought up to a level surface to fill up any openings between the interior stones due to inferior workmanship.

Spalls are broken pieces of stone.

Weathering.—When the face of a stone is inclined to the horizontal to throw off water it is said to be weathered, as in sills, cornices, etc.

Footings.—The object of footings is the same as in brick walls. Stone footings should be large rectangular blocks. Square stones in plan are not so good as oblong. All stones in the same course must be of the same height, but all courses need not necessarily be of the same depth. The breadth of set-offs need not exceed 3 or 4 inches.

Where the expense of stone is an objection, footings may be made of bricks or deep beds of concrete, as already described on page 16.

Bed Surface.—The bed surface must be worked in one plane surface. Masons to form thin joints often make the beds hollow; this is bad, as it is liable to spall; all the pressure will be thrown on the outer part, which is liable to flush or burst the face of the stone.

Galleting is the name given when sharp bits ot flint, called spalls, are inserted in the mortar of rubble walls to give a pleasing effect.

Dressings.—Stones are said to be dressed when their faces are brought to a fair surface; but any stones which are cut or prepared and are used as finishings to quoins, window and door openings, and may be applied as an ornamental feature, such as quoin stones, window and door jambs, are described as dressings.

Quoins.—In rubble and inferior stone walls, quoins are built of good blocks of ashlar stone to give strength to the wall. These are sometimes worked to give a pleasing effect, and when hammered, dressed and chamfered, as in figure 124, are said to be rusticated. They are, at times, merely built with a rough or quarry face, as in elevation figure 128.

Window and Door Jambs.—For purposes of strength these should be of cut stone, attention being given that each course is securely bonded. For that reason it would not be advisable to build them of rubble. Figures 112 and 113 show alternate courses, one showing the stones forming the window jambs acting as stretchers, and the other a through stone forming the face of reveal and the face of rebated jamb.

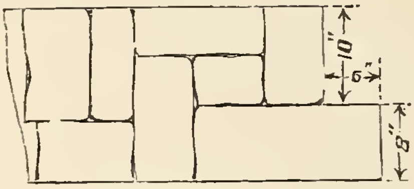


Fig. 112.

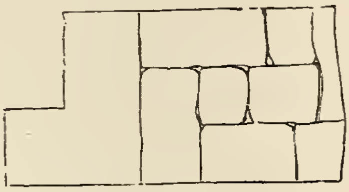


Fig. 113.

Sills are the lower horizontal members of openings, and those in stone are usually of one length, being pinned in cement to both sides of the opening. They should be fixed after the carcase of a building has been finished, and any settlement that was likely to occur through a number of wet mortar joints has taken place. They may be either plain and square, as in figure 409, or sunk, weathered, throated and grooved for metal water bar, as illustrated in figure 432.

Corbel is a piece of stone projecting from a wall to support a weight placed upon it, as in figure 230.

Skew Corbel is a projecting stone at the lowest part of the triangular portion of the gable end of a wall supporting the starting piece of coping, as shown in figure 116.

Kneeler.—The lowest stone of the triangular portion of a gable end of wall. It should be a long stone, to tail well into the wall, as shown in figure 115.

Saddle or Apex Stone.—Highest stone of a gable end cut to form the termination of two adjacent inclined surfaces, as shown in figure 114.

Lacing Course.—Owing to the absence of bond in flint walls, at intervals, courses of bricks, three or four deep, are inserted to give strength to the wall and bring it to a level surface. These courses do not always show on the outside.

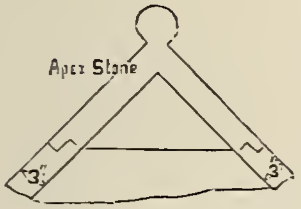


Fig. 114.

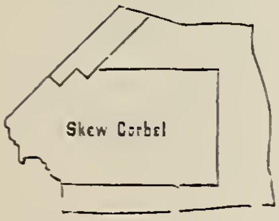


Fig. 116.

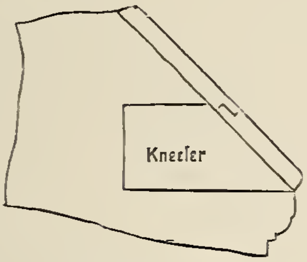


Fig. 115.

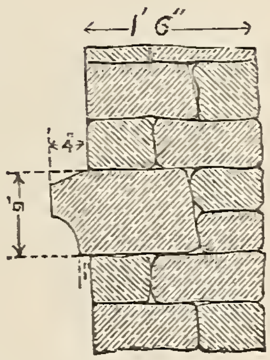


Fig 117.

Sometimes the name is applied to a horizontal band of stone placed in rubble walls to form a longitudinal tie.

String Courses are horizontal projecting bands of stone, as in figure 117, often carried below windows, and are of importance, imparting a feature to the building.

Plinth is a horizontal projecting course built at the base of a wall, often chamfered, as in figure 132. In a tuscan column it is the square member at the base.

Cornices.—The moulded course of masonry crowning buildings, generally having a large projection to throw off the rain.

Blocking Course.—A course of stones erected to make a termination to the cornice (see figure 130), the height of which should equal the projection of the cornice, and is often used as one side of a parapet gutter.

Copings are the highest and covering course of masonry, forming a waterproof top, to preserve the interior of wall from wet, which in frosty weather might burst the wall. Figures 118 and 119 show parallel copings which should be used only for inclined surfaces, as on a gable or in sheltered positions. Figures 120 and 121 give section and elevation of feather-edged copings, which throw water off on one side of walls, and are necessary for parapet walls of crowded thoroughfares. Saddle-back is the name applied when the upper surface is weathered both ways, as in figures 122 and 123, and segmental when the section of coping shows the upper surface to be a part of a circle, as in figures 126 and 127.

Throating are grooves on the under surfaces of copings, sills, string courses, etc., acting as drips for any water that would otherwise trickle down, and disfigure the walls, as in section, figure 123.

Templates.—A piece of stone placed under the end of a beam or girder to distribute the weight over a greater area, as in figures 163 and 164.

Labours.—The following are the chief labours adopted in preparing stonework :—Sawing, plain work, boasted, tooled, combed or dragged, vermiculated, pointed, moulded, sunk, and rubbed, which may be either straight or curved work; scabbling, hammer-dressed, and chisel-draughted margins.

Self Faced is the term applied to the quarry face, or the surface formed when the stone is detached from the mass in the quarry; also the surfaces formed when a stone is split in two.

Scabbling or Scappling.—That is, taking off the irregular angles of stone; is usually done at the quarry, and is then said to be quarry pitched, hammer faced, or hammer blocked; when used with such faces the stone is called rock or rustic work.

Hammer Dressing.—Roughest description of work after scabbling.

Chisel Draughted Margin.—To ensure good-fitting joints in hammer-faced stones, a smooth surface about an inch wide is cut with a chisel, forming a margin on the face of stone, as in figure 124.

Plain Work.—This is divided, for purposes of valuation, into half plain and plain work. The former term is used when the surface of the stone has been brought to an approximately true surface either by the saw or with the chisel. Plain work is the term adopted to surfaces that have been taken accurately out of winding with the chisel. These labours are usually placed upon the bed and side joints of stones in walling.

Rubbed Work.—This labour consists in rubbing the surfaces of stones until perfectly regular, and as smooth as possible. The work is accomplished by rubbing a piece of stone with a second piece. During the first stages of the process, water and sand are added, gradually reducing the quantity of sand up to the finish. Large quantities of stone are rubbed by means of large revolving iron discs, on which the stones are placed, and kept from revolving with the disc by means of stationary timbers fixed across the table a few inches above the same. Water and sand are added to accelerate the process. Only plane surfaces can be rubbed in this way.

Boasted or Droved Work.—This consists in making a number of parallel chisel marks across the surface of the stone by means of a chisel, termed a boaster, which has an edge about 2½″ in width. In this labour, the chisel marks are not kept in continuous rows across the whole width of the stone.

Tooled Work.—This labour is a superior form of the above, care being taken to keep the chisel marks in continuous lines across the width of the stone. The object of this and the preceding is to increase the effect of large plane surfaces by adding a number of shadows and high lights.

Combed or Dragged Work.—This is a labour employed to work off all irregularities on the surfaces of soft stones. The drag or comb is the implement used, and consists of a piece of steel with a number of teeth like those of a saw. This is drawn over the surface of the stone in all directions, making it approximately smooth.

Vermiculated Work.—This labour is placed chiefly on quoin stones to give effect. The process is as follows:—A margin of about ¾″ is marked about the edge of the stone, and in the surface enclosed by the margin a number of irregularly shaped sinkings are made. The latter have a margin of a constant width of about ⅜″ between them. The sinkings are made about ¼″ in depth. The sunk surface is punched with a pointed tool to give it a rough pocked-mark appearance.

Pointed Work.—The bed and side joints of stones are often worked up to an approximately true surface by means of a pointed tool or punch. This labour is often employed to give a bold appearance to quoin and plinth stones, and where so used it usually has a chisel-draughted margin about the perimeter.

Moulded Work.—Mouldings of various profiles are worked upon stones for ornamental effect. Mouldings are worked by hand as well as by machine. In the former case, the profile of the moulding is marked on the two ends of the stone to be treated by means of a point drawn about the edge of a zinc mould, cut to the shape of the profile. A draught is then sunk in the two ends to the shape of the required profile. The superfluous stuff is then cut away with the chisel, the surface between the two draughts being tested for accuracy by means of straight edges. The machines for moulded work somewhat resemble the planing machines for metal work. The stone is fixed to a moving table. The latter has imparted to it a reciprocating rectilinear motion, pressing against a fixed cutter of the shape of required profile, or some member of it. The cutter is moved nearer to the stone after each journey, thus gradually removing the superfluous stuff till the profile is completed. Moulded work is, strictly speaking, the name given to profiles formed with a change of curvature, and, therefore, should not be applied to cylindrical sections, such as columns.

Moulded Work, Circular.—This term is given to mouldings stuck upon circular or curved surfaces in plan or elevation.

Sunk Work.—This term is applied to the labour of making any surface below that originally formed, such as chamfers, wide grooves, the sloping surfaces of sills, etc. If the surface is rough, it is known as half-sunk; if smooth, sunk; and any other labour applied must be added to the same, such as sunk, rubbed, etc.

Circular Work.—Labour put upon the surface of any convex prismatic body, such as the parallel shaft of a column or large moulding, is termed circular work.

Circular Sunk Work.—Labour put upon the surface of any concave prismatic body, such as a large hollow moulding or the soffit of an arch, is termed circular sunk work.

Circular Circular Work is the labour placed upon columns with entases, spherical or domical work.

Internal Mitres is the name given to the intersection of two mouldings making an angle less than 180°.

External Mitres is the name given to the intersection of two mouldings making an angle greater than 180°.

Returned Mitred and Stopped is the name given to a moulding returned in itself, and stopping the same against an intersecting surface, as shown in enlarged detail Building Plate, No. 9.

Long and Short Work.—This work is usually used for quoins and dressings in rubble walls, and is especially noticeable in old Saxon work. It consists in placing alternately a flat slab, which serves as a bonder, and a long stone approximately small and square in section.

This work is sometimes known as block and start work.

Stone Walling may be divided under the following headings :

1. Rubble. 2. Block in course. 3. Ashlar.

Rubble walls are those built of thinly-bedded stone, generally under 9 inches in depth, of irregular shapes as in random rubble, or squared as in coursed rubble.

Block in course is composed of squared stones usually larger than coursed rubble, and under 12 inches in depth.

Ashlar is the name given to stones, from 12 to 18 inches deep, dressed with a scabbling hammer, or sawn to blocks of given dimensions and carefully worked to obtain fine joints.

The length of a soft stone for resisting pressure should not exceed three times its depth; the breadth from one-and-a-half to twice its depth; the length in harder stones 4 to 5 times its depth, and breadth 3 times its depth.

Random Rubble is the name given to stones that are not squared.

Random Rubble set Dry.—In the stone districts boundary walls are built of rubble set without mortar in courses about 12 inches high, provided with a waterproof top to keep water from getting into the body of work, and bursting it in frosty weather.

Uncoursed Random Rubble set in Mortar.—The stones are used as they come from the quarry, care being taken to select them as uniformly as possible, the bond being obtained by fitting in the inequalities of the stone, and by using one bond stone every super yard on face; any openings between stones to be pinned in with spalls. If good mortar is used, walls built of random rubble should be made one-third thicker than that necessary for brick walls.

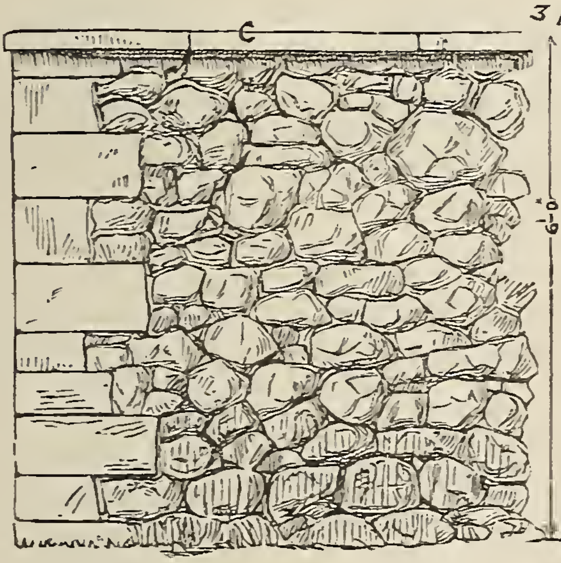


Fig. 118.

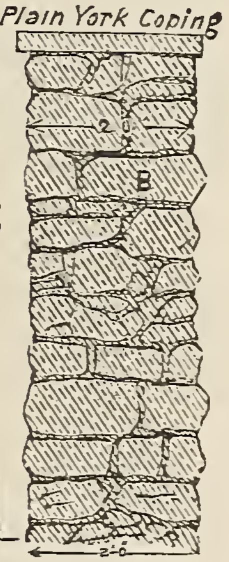


Fig. 119.

In the following figures P stands for plinth, B for bonder and C for coping. Figures 118 and 119 show elevation and section respectively.

Random Rubble built in Courses.—This consists in forming horizontal beds at intervals of 12 to 18 inches, every stone being bedded in mortar. The object being to ensure that there shall be no continuous vertical joints, as illustrated in figures 120 and 121. To save expense in bedding each stone in mortar, masons bed only the stones on faces of wall (which, by the way, is not a good practice), and at these levels

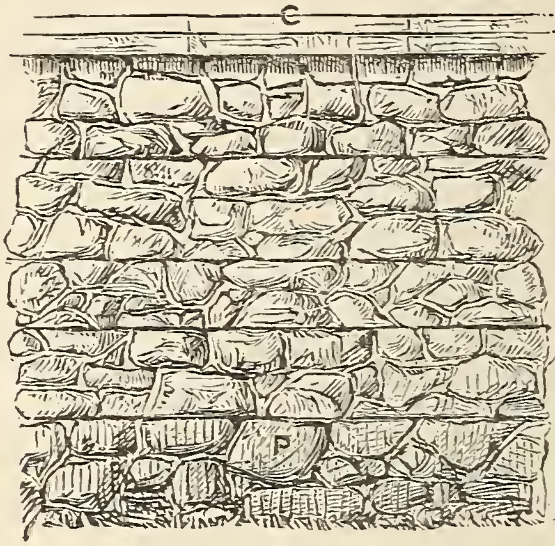


Fig. 120.

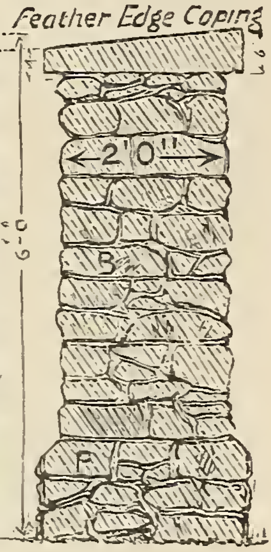


Fig. 121.

pour a pail of thin mortar, called grout, to fill up any cross joints between stones, taking care not to let any run over the face of wall.

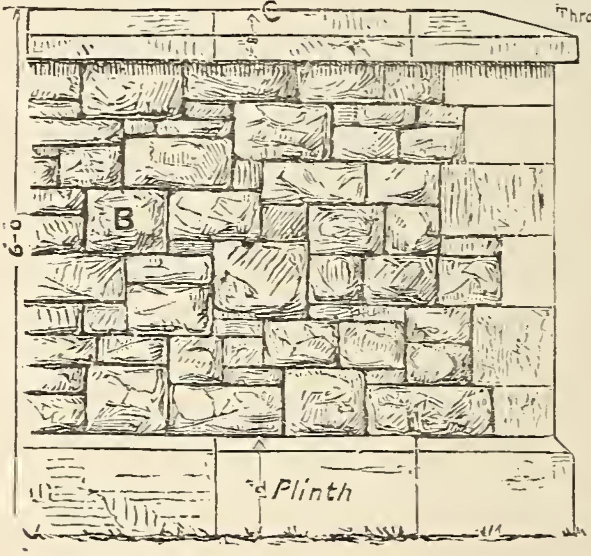


Fig. 122.

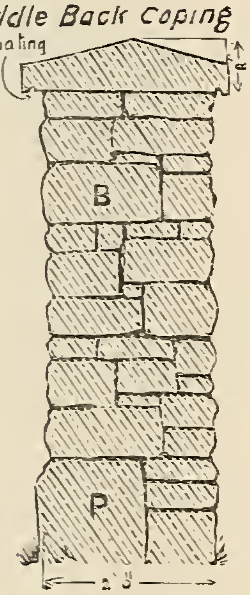


Fig. 123.

Uncoursed Squared Rubble, sometimes called irregular coursed or snecked rubble, are stones roughly squared and hammer or axe faced, the vertical depth of the stones usually being less than 9", as shown in figures 122 and 123.

Squared Rubble built in Courses.—Figures 124 and 125 show squared rubble brought up to level beds with hammer-dressed quoins and chisel-draughted margins.

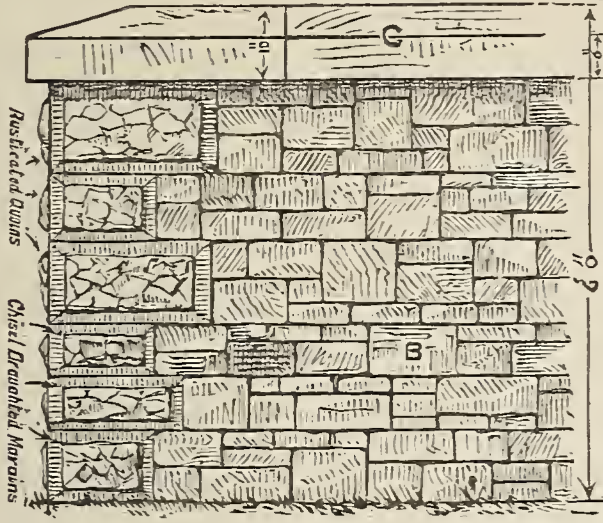


Fig. 124.

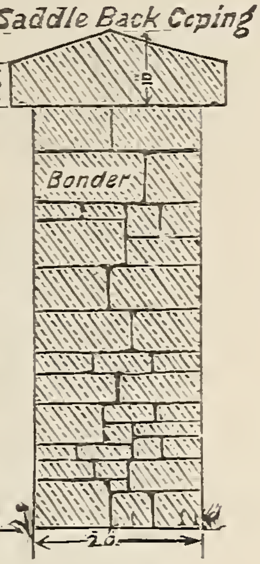


Fig. 125.

Regular Coursed Rubble.—In this kind of work all stones in one course are squared to the same height, usually

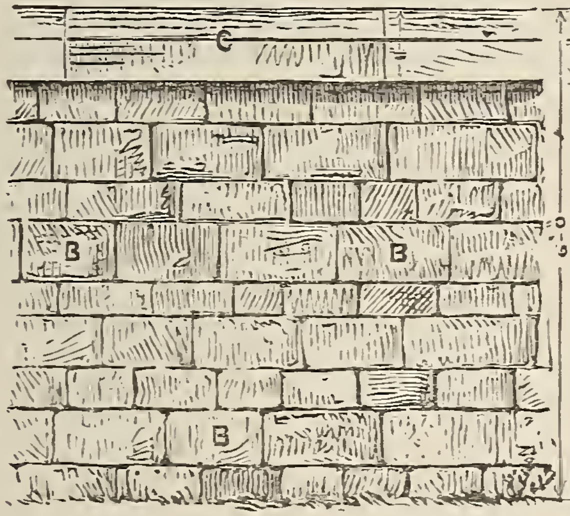


Fig. 126.

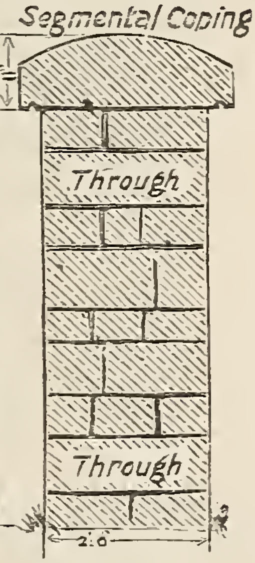


Fig. 127.

varying from 4″ to 9″, as illustrated in figures 126 and 127, and are generally obtained from thin but regular beds of stone.

Block in Course is the name applied to stone walling, chiefly used by engineers in embankment walls, harbour walls, etc., where good work is required. The stones are all squared and brought to good fair joints, the faces usually being hammer-dressed. Block in course closely resembles coursed rubble, or ashlar, according to the quality of the work put upon it.

Ashlar.—Ashlar is the name applied to stones that are carefully worked, and are usually over 12″ in depth, and have joints not more than $\frac{1}{8}$ inch thick.

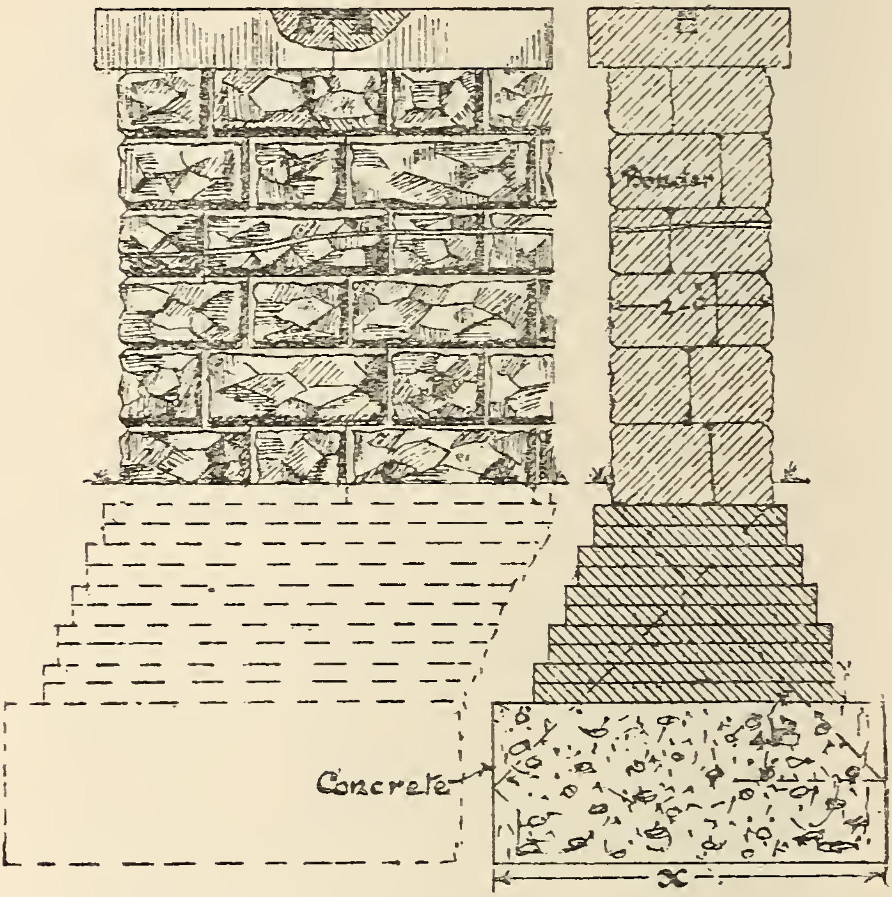


Fig. 128. Fig. 129.

As the expense would be too costly to have walls built entirely of ashlar, they are constructed to have ashlar facing and rubble backing, as in figures 130 and 131, or ashlar facing and brick backing, as in figures 132 and 133; but, as the backing would have a greater number of joints than the ashlar, the backing should be built in cement mortar, and brought to a level at every bed joint of the ashlar, to ensure equality of settlement.

The ashlar facing may be plain, rebated, or chamfered, as illustrated in figure 132, and looks best when laid similar to Flemish bond in brickwork.

Fig. 130.

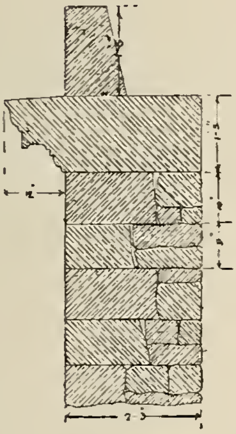
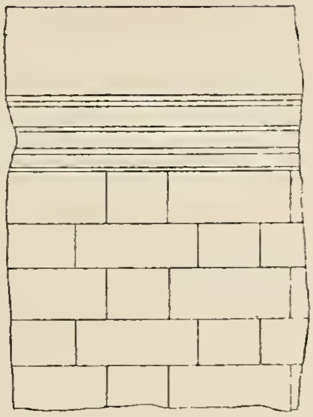


Fig. 131.



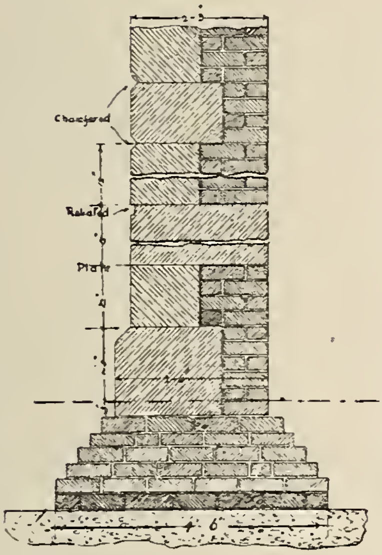


Fig. 132.

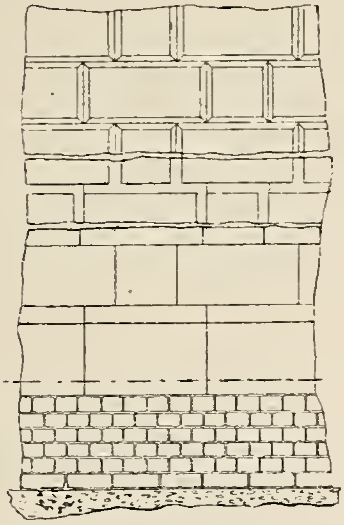


Fig. 133.

Joggles.—A joggle is a form of joint in which a portion of the side joint of one stone is cut to form a projection, and a corresponding sinking is made in the side of the adjacent stone for the reception of the projection, as shown in figures 134 and 135. It is chiefly used in landings to prevent any movement between the stones joined and so retain a level surface between same, and also to assist in distributing any weight over every stone in the landing.

Tabling Joint.—This is a form of joint that has been used to prevent lateral motion in the stones of a wall subjected to lateral pressure, such as in a sea-wall. It consists of a joggle joint in the bed joints, the projection in this case being almost $1\frac{1}{2}''$ in depth and a third of the breadth of the stone in width, as shown in figure 136. This kind of joint is rarely used now owing to the great expense in forming same, it being superseded for sea-walls by huge blocks of concrete cast on or near the spot, of a weight sufficient to resist any pressure likely to be brought to bear on the same, and usually under other conditions by long slate joggles placed in a space to receive same in the bed joint at the junction of side joints of two stones and the top bed joint of another, as shown in figure 137. These were used in the piers of the new Tower Bridge.

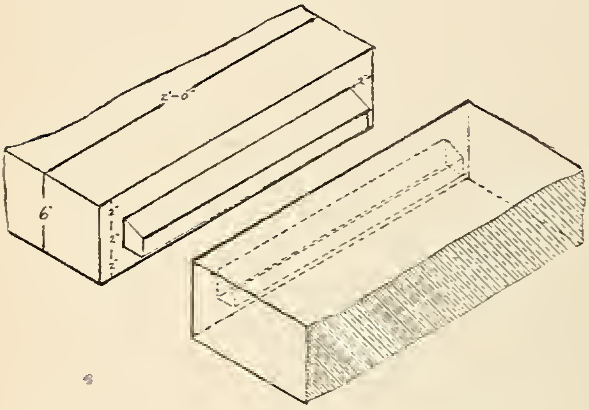


Fig. 134. Fig. 135.

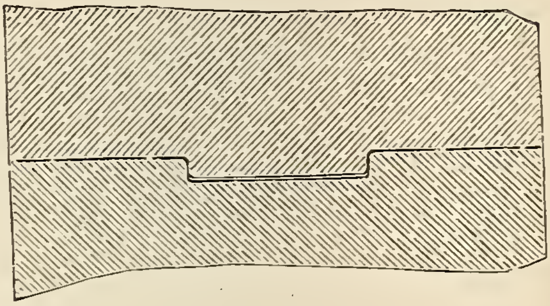


Fig. 136.

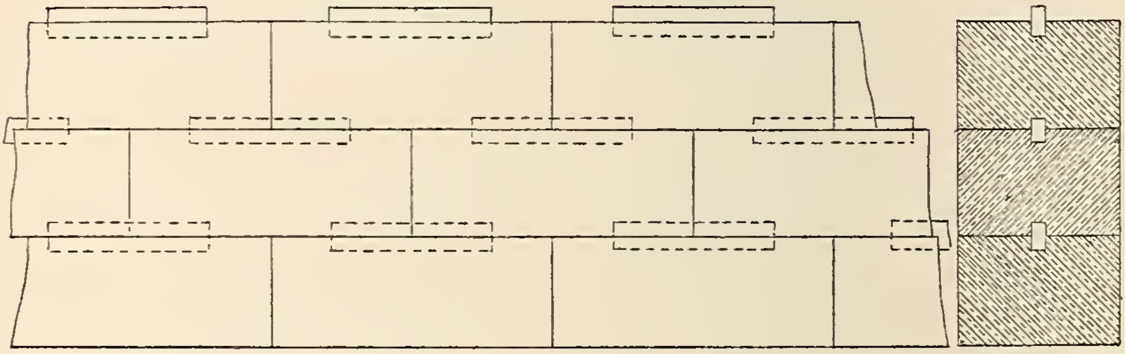


Fig. 137.

Cement Joggles.—These are generally used in the side joints of the top courses of masonry to prevent lateral movement in same, and consist of a V-shaped sinking in the side joint of each adjacent stone in the same course, as shown in figure 138.

Dowels.—Dowelling is another method of obtaining the same result as with joggling or tabling. The dowels consist usually of pieces of hard stone or slate about 1 inch square in section and varying from about 2 inches to 5 inches in length, slightly tapering from the centre towards the two ends, as shown in figure 140, being sunk and set in cement in corresponding mortises in the adjacent stones. They are used in both the side and bed joints. They are generally employed in the top courses of masonry where the weight on or of the individual stones is not great. The united mass thus formed from the collected stones renders any movement impossible under normal conditions.

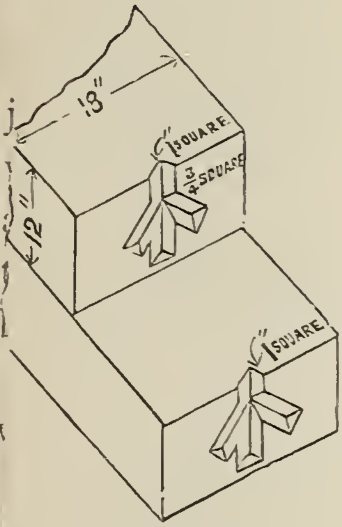


Fig. 138.

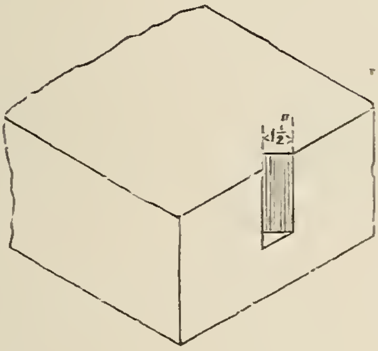


Fig. 139.

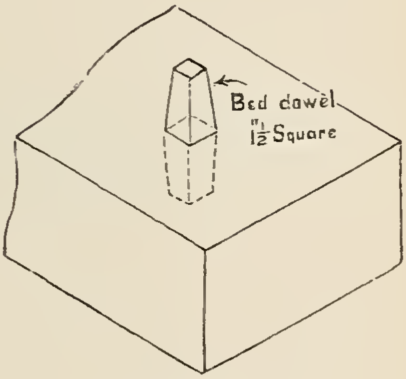


Fig. 140.

Pebbles.—Small pebbles used to be commonly employed to connect stones before the introduction of slate joggles owing to the ease with which the latter may be fitted. The pebbles are still sometimes used for small work.

Cramps.—Metal cramps are used to bind work together similar to dowels but are more particularly adapted for positions in which there is a tendency for the stones to come apart, such as in copings covering a gable, or in face stones of no great depth, or cornices and projecting string courses to tie the same to the body of the wall. The cramps are made from thin pieces of metal of varying lengths and sectional area according to the work, turned down about 1½″ at each end. The ends are made rough and inserted into mortises, and the body of the cramp into dovetailed shaped mortises, and a chase made to receive same in the stones to be connected, as shown in figures 141, 142. The cramps are usually prepared from either wrought iron, copper, or bronze. If wrought iron is used it is usually subjected to some preservative process, such as tarring and sanding or galvanizing, to prevent oxidation. Iron is useful on account of its great tensile strength. Copper is valued for its non-corrosive properties under ordinary conditions and its tensile strength, which is not much less than wrought iron; it is, however, comparatively soft. Bronze partakes of properties similar to those of copper with the exception that it is much harder, which under some conditions is a desideratum.

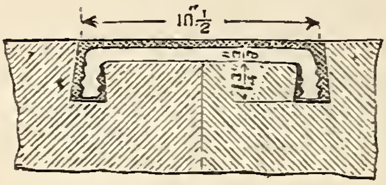


Fig. 141.

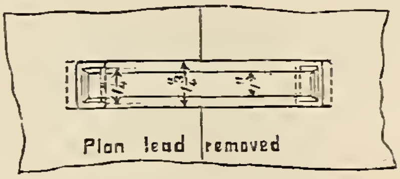


Fig. 142.

The best bedding materials are Portland cement, sulphur and sand, and asphalte. Care should be taken to completely envelope the cramp in the bedding material. Lead is not now considered good for external work owing to its liability to form a galvanic couple with the cramp in the presence of moisture, in addition to the oxidation. Occasionally stones are connected by slate cramps set in cement, as shown in figure 143.

Lead Plug.—Stones may be connected together by means of lead in the following manner, shown in figures 144 to 146 :—Dovetailed shaped mortises of the form shown are made to correspond in the side joints of two adjacent stones, which, when placed in position, has molten lead poured upon it, and when cool is caulked, thus completely filling the mortises and connecting the pieces.

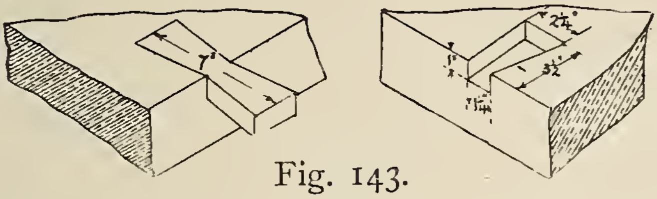


Fig. 143.

Rag Bolt.—The ends of the bolts are often fixed by having the end that is let into the stone jagged, and is run with lead, or sulphur and sand, the mortises being dovetail shaped, as in figure 147, to secure them from any upward pressure.

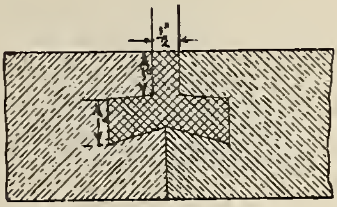


Fig. 144.

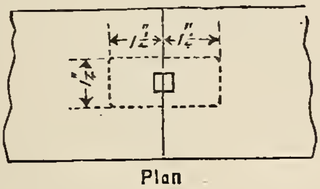


Fig. 145.

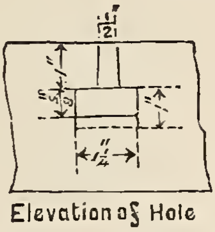


Fig. 146.

Where there is any probability of a great upward stress a hole is drilled right through the stone and a bolt supplied with a washer passed through in the ordinary manner.

Saddled or Water Joint.—To protect the joints of cornices and other exposed horizontal surfaces of masonry the sinking is sometimes stopped before the joint and weathered off, as shown in figures 148 and 149. Any water passing down the weathered surface is guided away from the joint. The expense of this joint often prohibits its use.

Rebated Joint.—This is a joint used for stone roofs and copings to obtain a weather-tight joint. They are of two kinds: (1) when both stones are rebated; (2) when the upper stone only is rebated. In the first case the stones are of the same thickness throughout, their upper surface being level when the joint is made. In the second case the stones are thicker at the bottom edges than at the top, the bottom edge having a rebate taken out equal to the thickness of the upper edge of the stone below it, over which it fits. The part that laps over should not be less than $\frac{3}{4}''$ thick. The under surface or beds of the stone should be level, as shown in figure 150.

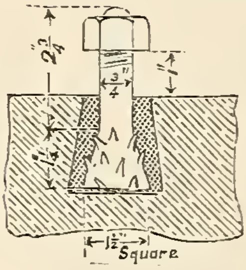


Fig. 147.

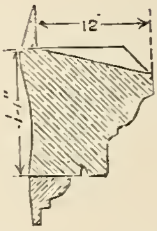


Fig. 148.

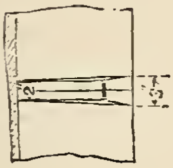


Fig. 149.

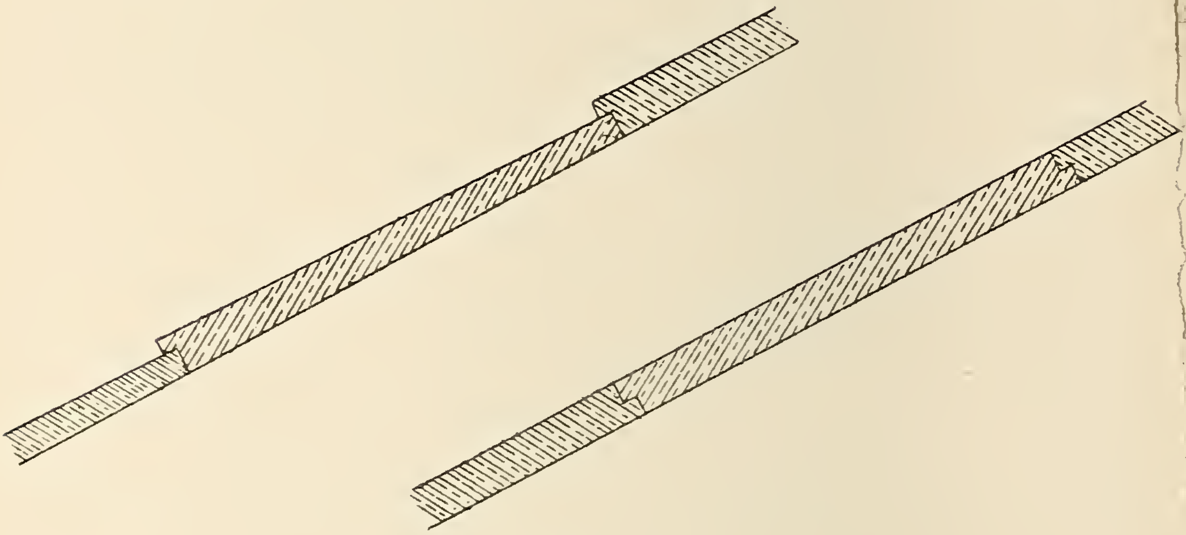


Fig. 150.

Stone Arches.—The general remarks, definitions, terms, etc., made in the last chapter on brick arches, apply also to the stone arches, differing only slightly in construction. The openings in stone of small span are generally bridged by stone lintels in one piece, or lintels built on an arched construction if a number of stones are used. If lintels of one piece are employed in walls other than ashlar, a rough arch is generally built above to relieve the lintel of the weight of the superincumbent wall, as shown in figure 151. One type of a rough arch is shown in figure 152, showing the arch formed in the depth of the course above the lintel.

Figures 153, 154, 155 show methods of constructing lintels, the first example being an ordinary flat arch having a rectangular slate or stone key, or joggle, let in the centre of the bed joint between every pair of stones, thus preventing sliding taking place. The second example having a semicircular joggle running from front to back of every pair of bed joints, which latter are kept vertical. Figure 155 is constructed of a proper flat arch, the bed joints having two faces to increase the strength of the same. This method is very largely used in both stone and terra-cotta.

Figure 156 shows a semicircular stone arch built in brickwork.

In striking these arches the voussoirs are divided up equally on the soffit, and the bed joints are struck radially from the centre.

The greatest width of the voussoirs is made to equal some multiple of the thickness of a brick, 3, 4, or 5 courses as required. The first bed joint is produced till it cuts the bed joint of the bricks desired. The boundary of the voussoir is from this point deflected horizontally for about 4″ to 6″ and vertically upwards for another 4 or 5 courses, the second radial joint is then struck and produced to the same level; these two points are joined by a horizontal line and the second voussoir is completed. This operation is repeated till the arch is finished. It should be observed that the depth of the arch increases towards the crown, as set out by this method.

In all wrought stonework the voussoirs are accurately set out with templets, and cut.

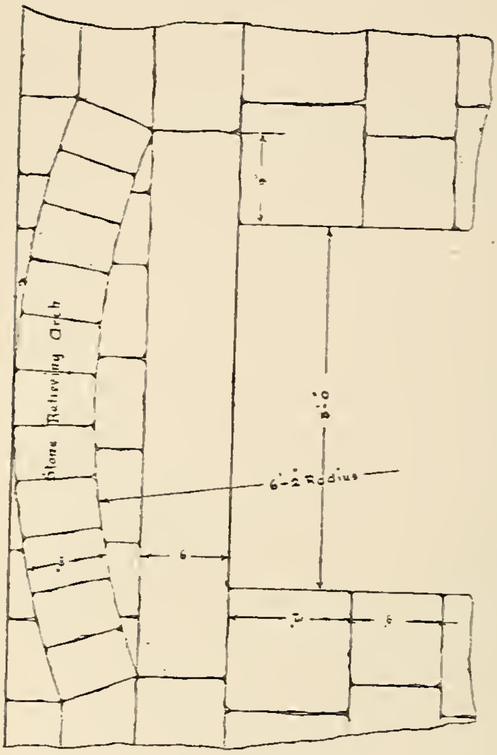


Fig. 151.

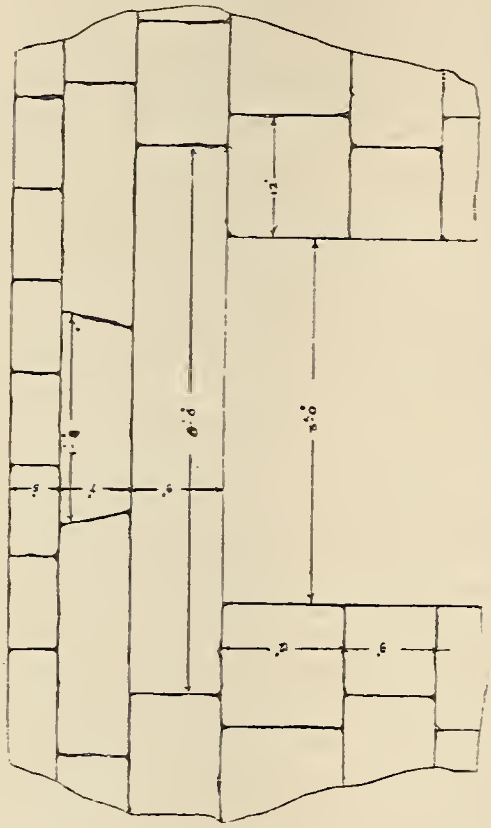


Fig. 152.

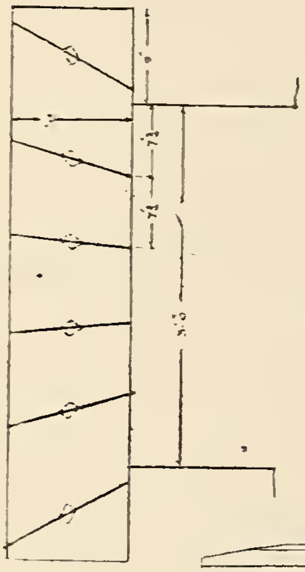


Fig. 153.

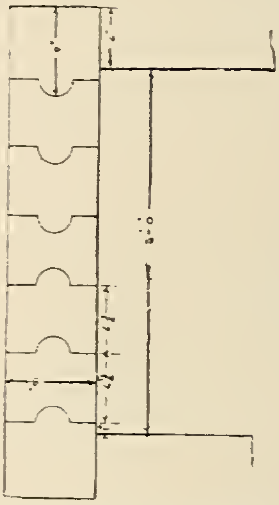


Fig. 154.

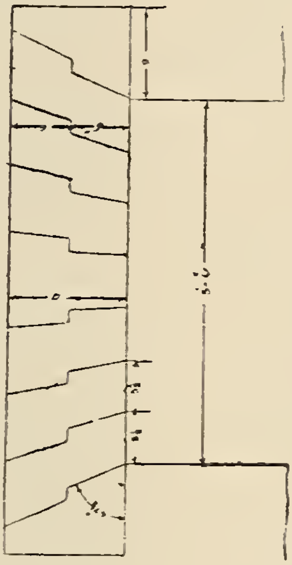


Fig. 155.

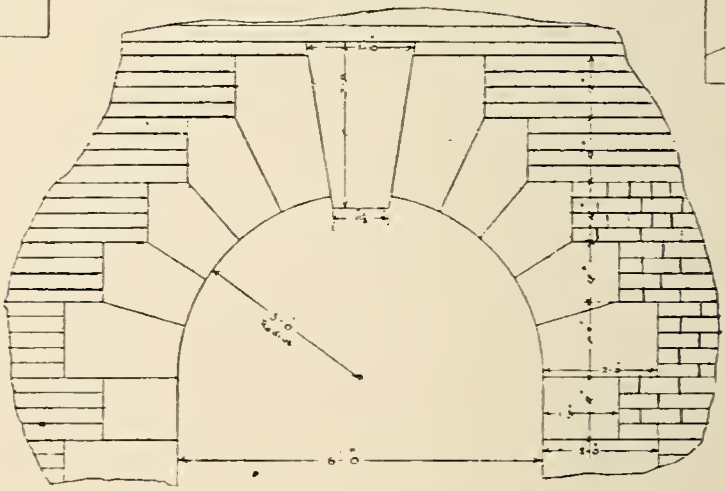


Fig. 156.

CHAPTER IV.

GIRDERS.

Definition.—Members of buildings which are in one piece, or built up to form one member and used to span openings and support loads, are called girders, and may be either straight or curved and of various sections.

Classification.—They may be of (*a*) wood, (*b*) wood, halved, reversed and bolted, (*c*) flitched beams, (*d*) built-up beams, (*e*) trussed beams, and when entirely of metal may be of cast iron, wrought iron or steel. The sections of the two latter may be rolled or built up as plate, box, lattice, Warren girders, etc.

Girders fixed at one end and free at the other are called semi-beams or cantilevers, and beams when supported or fixed at both ends.

A load carried by a beam supported only at its ends would cause the upper fibres of the beam to be in compression, and the lower to be in tension. The neutral plane is an imaginary plane containing the fibres in that part of the beam which is neither in tension or compression.

Bressummer, or breastsummer is a girder with a wide supporting surface, acting as a lintel; as in the case of a beam supporting a brick wall over a shop front.

Wood Girders.—These are formed by sawing, reversing, and bolting timber, as in figures 157 and 158. By reversing is meant not only turning the cut faces outside, to detect any defects and to ensure its being thoroughly seasoned, but also to change the ends, so that the butt end of one piece is against the top end of the other, which ensures equal strength throughout.

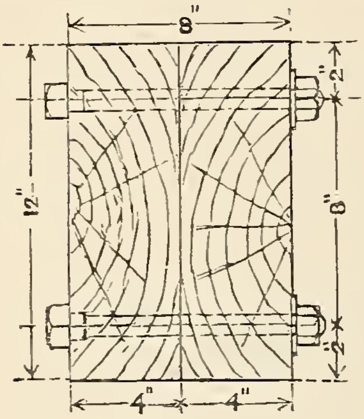


Fig. 157.

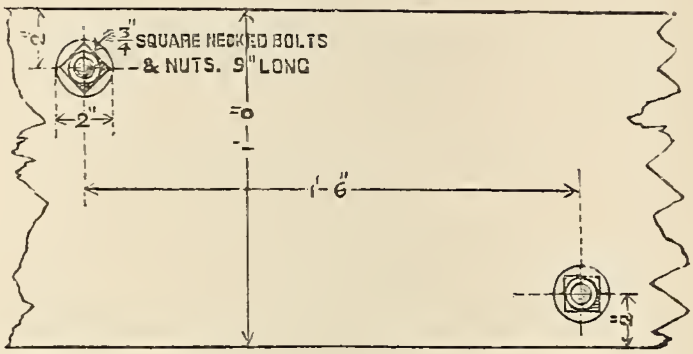


Fig. 158.

Flitch Girder.—To further strengthen a wood girder, a wrought iron plate or flitch is inserted between the cut timber and bolted, as shown in figures 159 and 160. To prevent the iron girder riding on the iron flitch when the timber shrinks, the iron is kept $\frac{1}{4}''$ from the top and bottom surfaces.

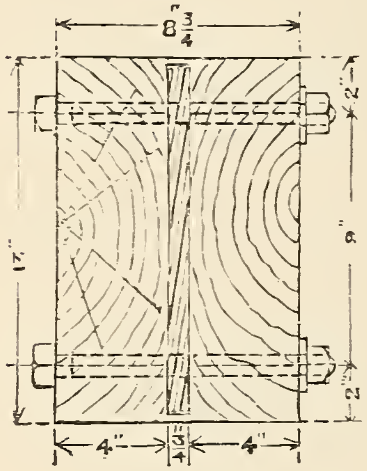


Fig. 159.

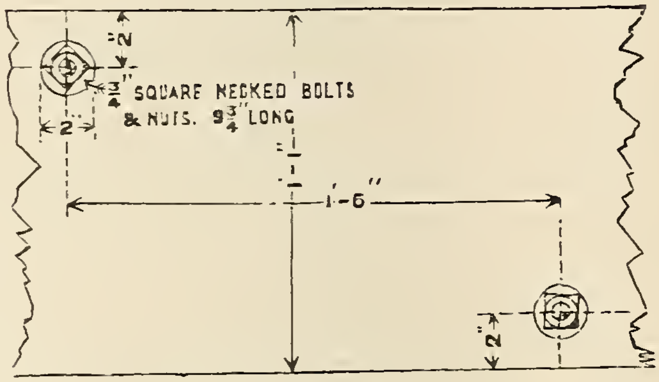


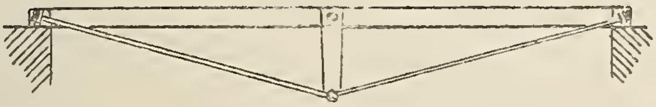
Fig. 160.

Built-up Beams.—Wood beams that are required of a length not obtainable in the market, are sometimes built up in layers.

When built up with horizontal layers they are said to be laminated; but if layers are placed vertically they are said to be laid depthwise. The laminated method has been extensively used for curved beams or ribs of roofs, as works of curvature can be readily made by this method, but they do not possess the strength of the same quantity of material placed vertically. They are not much used now in horizontal positions.

Trussed Wood Beams.—It has been suggested that a material more adapted to resist tension, if placed at the bottom, would materially and economically strengthen the same, by enabling the timber to withstand the compression for which it is well adapted, and using the iron to withstand the tensional stress, for which it is eminently suitable. Figures 161 and 162 show the types which are greatly employed for the beams of travellers.

Fig. 161.



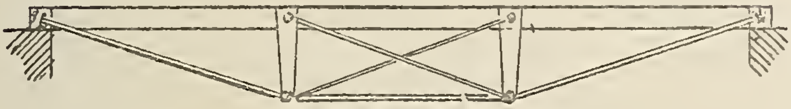


Fig. 162.

Technical Terms.—The following are some of the terms used in iron girder construction:—

Clear Span is the horizontal distance between the abutments.

Effective Span is the distance between the centres of the bearing surfaces of the girder on the supports, and is taken in the event of the camber of the girder preventing the bearing surface of the girder resting on the stone template.

Effective Load is the effective span in feet multiplied by the weight of the distributed load per foot run.

Bearing Surface is that part of the lower face of the girder when loaded which rests upon the support.

Total Length of the girder is the length to the edge of the bearing surfaces, plus the length of the bearing surfaces.

Effective Depth is the distance between the centres of gravity of the flanges.

"Feathers" are triangular fillets inserted at the angles of cast-iron girders, etc., usually making angles of 135° with the horizontal and vertical faces; right angles in cast iron are a source of weakness.

Camber.—Cast-iron girders should have a camber of $\frac{3}{4}$ inch to every 10 feet of span; wrought-iron and steel girders $\frac{1}{2}$ inch in 10 feet.

The best shape for cast-iron beams is that of I section, the tensional flange being four to six times the area of compressional flange.

The depth is usually about $\frac{1}{15}$ the length, and the width of compressional flange $\frac{1}{30}$ to $\frac{1}{40}$ the length.

All castings should vary in thickness gradually, and stiffeners should be cast about every 3 feet apart.

Sharp corners are a source of weakness, and should be well rounded; or triangular fillets, called feathers, cast at all internal angles.

The metal should preferably be good soft grey cold blast iron, sound and clean, cast from the second melting.

Figures 163 and 164 show section and part elevation of a cast-iron girder used as a beam, supported at the ends, resting on stone template, the top flange being in compression and the bottom flange in tension.

Cast-iron Cantilever.—Figures 165 and 166 show section and part elevation of girder, fixed one end and free at the other. This is sometimes called semi-beam or cantilever, and the upper would be the tensional flange and the lower the compressional flange, the strains induced being exactly opposite to those set up in the corresponding upper and lower flanges of the beam.

Figure 167 is a section of a cast-iron girder fixed at both ends, where each flange would at different parts be under

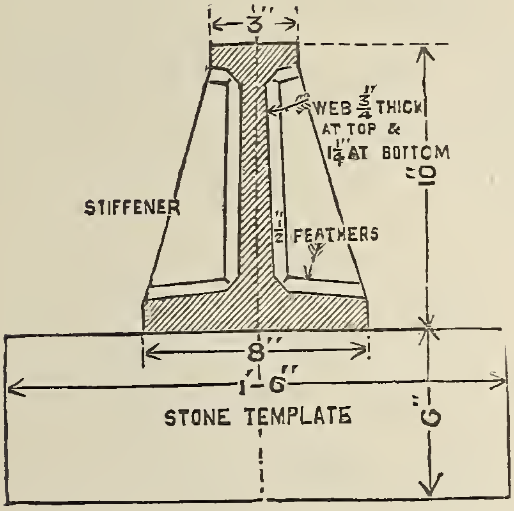


Fig. 163.

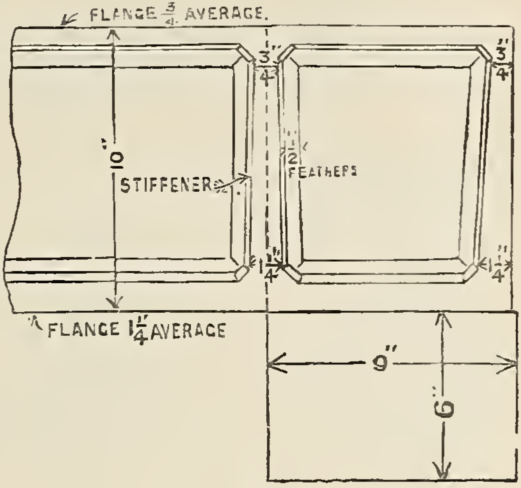


Fig. 164.

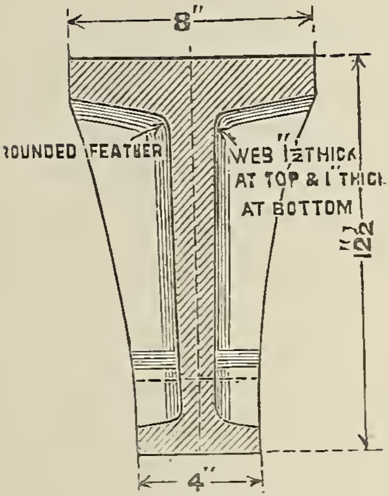


Fig. 165.

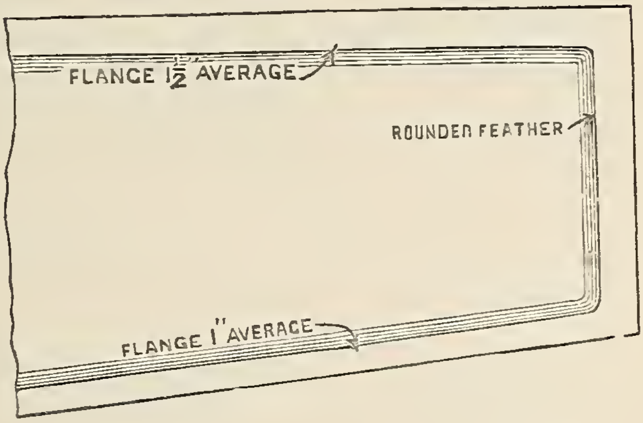


Fig. 166.

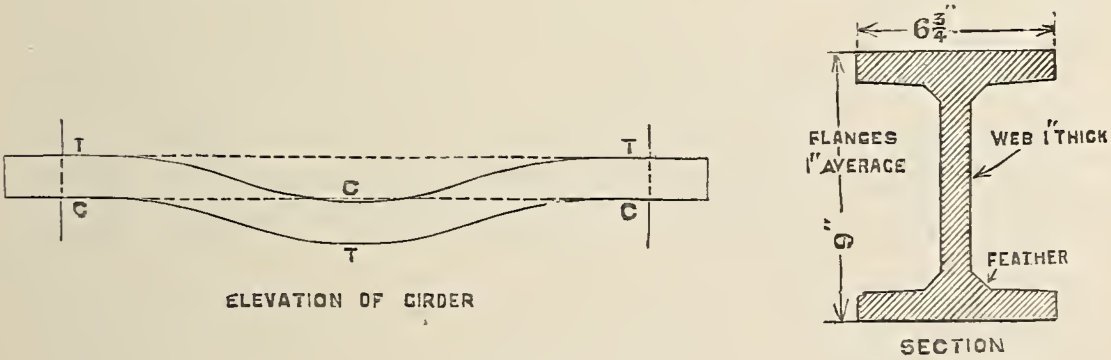


Fig. 167.

tensional and compressional stresses. Beams are said to be fixed when they are bolted at the ends, or if continued over a number of supports, the parts over the inner spans may be considered as fixed.

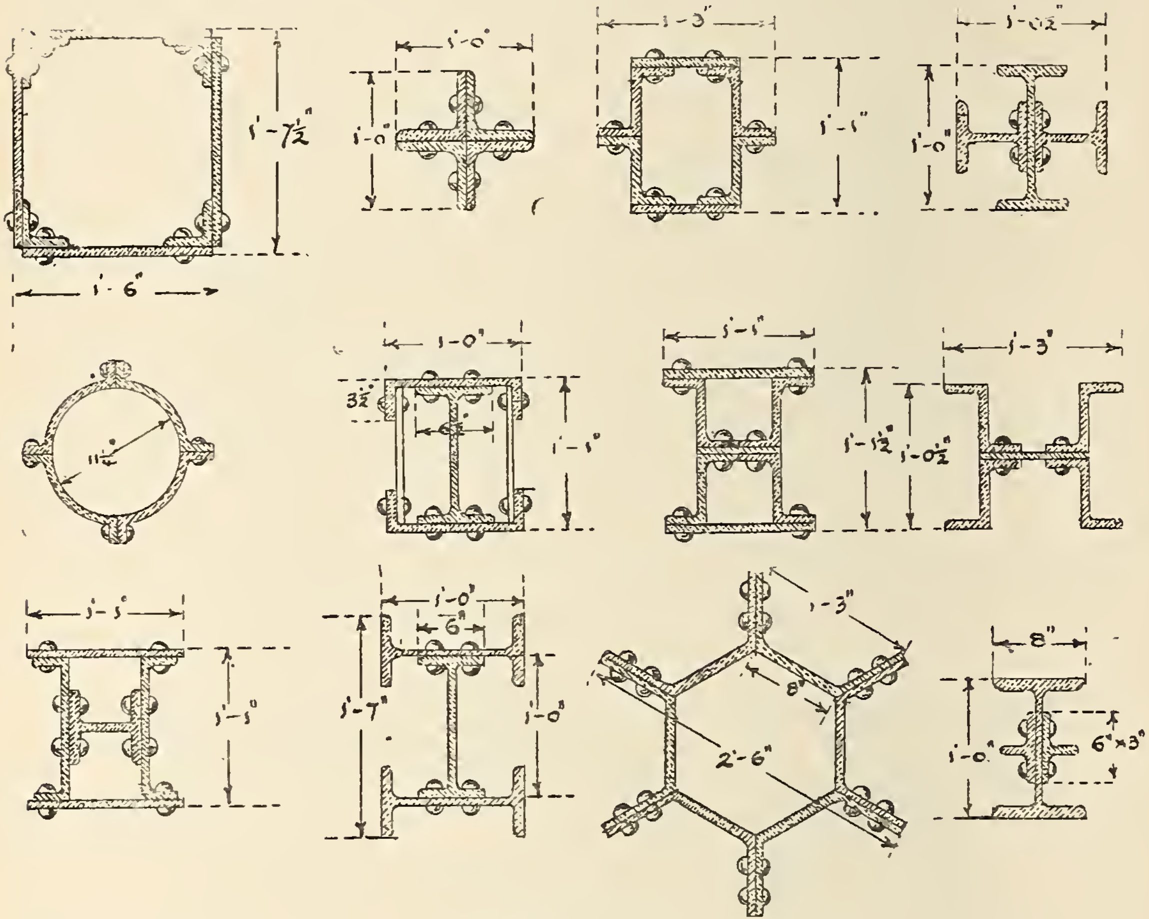
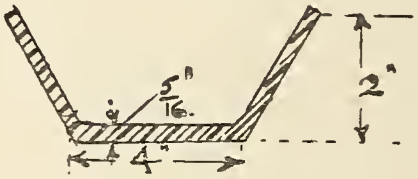


Fig. 168.



4" 2"×$\frac{5}{16}$" to 9"×6"×½'

Fig. 169.

Cast-iron girders are not considered as reliable as wrought-iron girders, as they may contain serious flaws hard to detect, and do not equally well withstand sudden changes of temperature. Cast-iron girders have snapped suddenly when cold water has been thrown upon them while they have been in a heated state, as is often the case in a burning building.

Wrought Iron and Steel Girders.—Owing to the above defects in cast iron, and the great improvement in the manufacture of wrought iron and steel, which can readily be obtained of numerous sections, notably those shown in figures 168 and 169, girders of the two latter materials have come greatly into use. They can be adapted with facility to any of the requirements of construction, and may be satisfactorily tested by taking small pieces of the material used, and subjecting them to the stresses they are required to resist. Heat causes wrought iron and steel to expand considerably, for which reason girders of these materials should never be fixed at both ends.

The following table shows the relative strengths in tons of cast iron, wrought iron, and steel, as most commonly used in ordinary construction :—

	Tension.	Compression.	Shearing.
Cast Iron	7 to 8	40 to 45	12
Wrought Iron ...	25	16 to 17	22
Steel	30	30	24

Wrought iron crushes with an average of 17 tons, and fails in tension with a pull of 22 tons. In practice, for small beams this difference is disregarded, and joists are rolled with two equal flanges, which can be easily obtained to a depth about 20 inches. Figures 170 and 171 show section and part elevation of a rolled iron joist.

Many forms of composite and patent girders are constructed by riveting plates to the flanges of rolled iron joists.

Plate Girders.—For girders over 12 inches in depth it is considered more economical to build them of riveted plates, angles and ⊤ irons, and to strengthen the webs and flanges with stiffeners of ⊤ or angle irons. Stiffeners may be simply angle or tee irons, cut to fit and riveted between the flanges and against the longitudinal angle

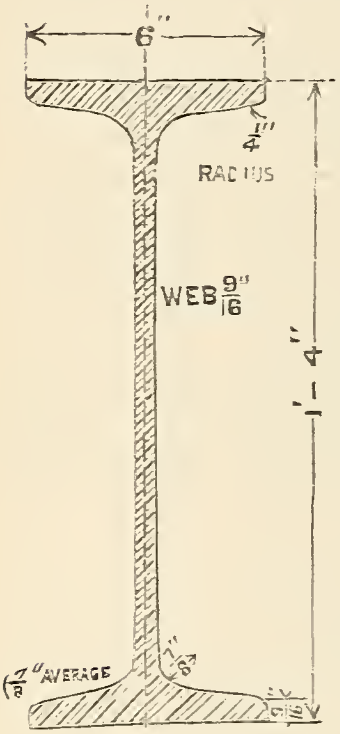


Fig 170.

Fig. 171.

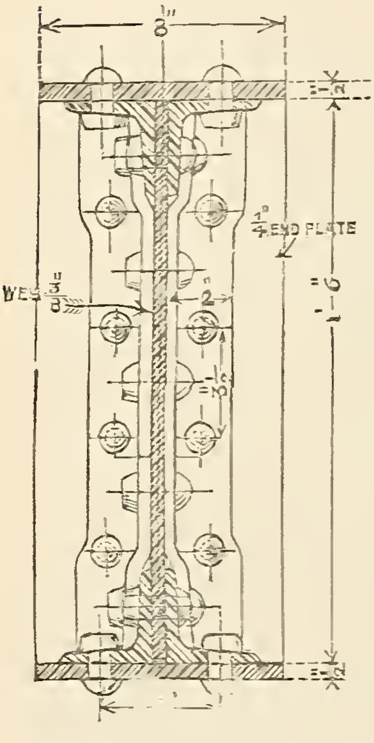


Fig. 172.

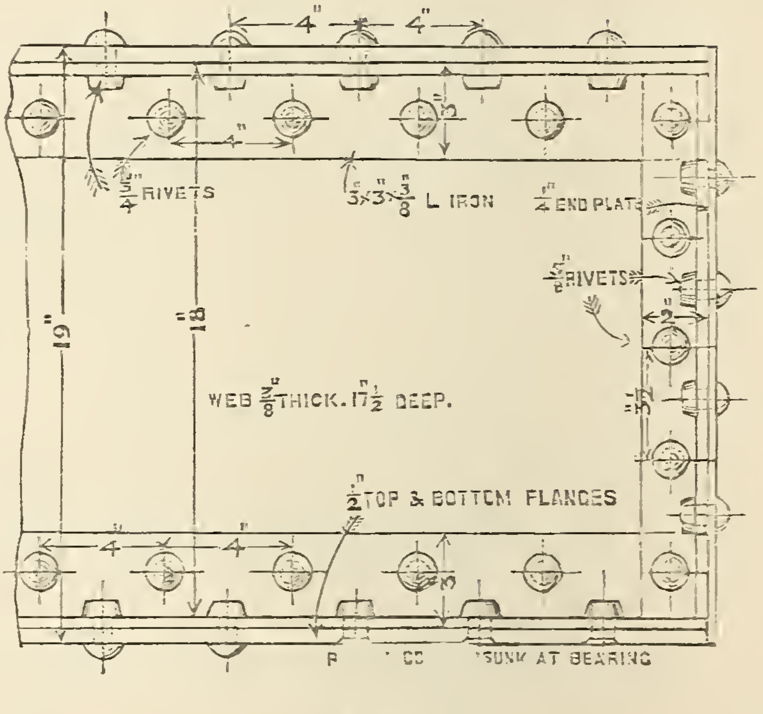


Fig. 173.

irons, a level surface being made with the latter; a vertical packing piece having a width equal to the stiffener and of the thickness of the longitudinal angle irons. Figures 172 and 173 show section and part of fixing end plates. The connecting angle pieces shown in these figures are bent, and though they dispense with packing pieces, are more expensive.

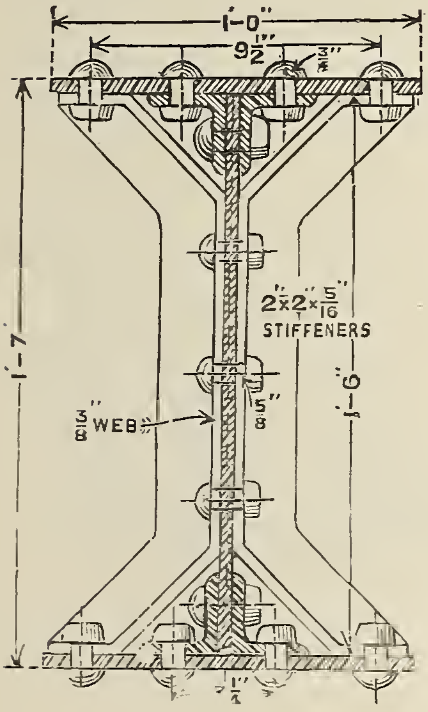


Fig. 174.

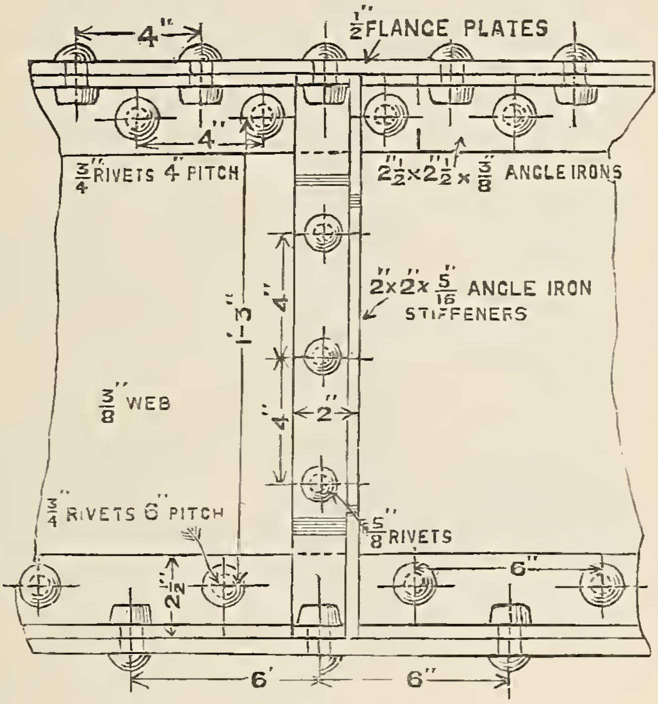


Fig. 175.

Figures 174 and 175 show section and part elevation of plate girder with cranked stiffener.

Box Girders.—When girders are required for large spans, such as 50 feet or more, they may be constructed with two webs. These are stronger than plate girders of equal section, and not so liable to twist laterally, owing to the greater support offered hem by the webs. Figures 176 and 177 show this method.

They should, however, be used only when large enough to be painted inside, and for this purpose the end plates should not be riveted to the body of the girder, but fixed inside to short angle irons by screw bolts.

Warren and Lattice Girders.—Girders required of considerable depth with the minimum quantity of material, are often made on the principle of the truss, as shown in figures

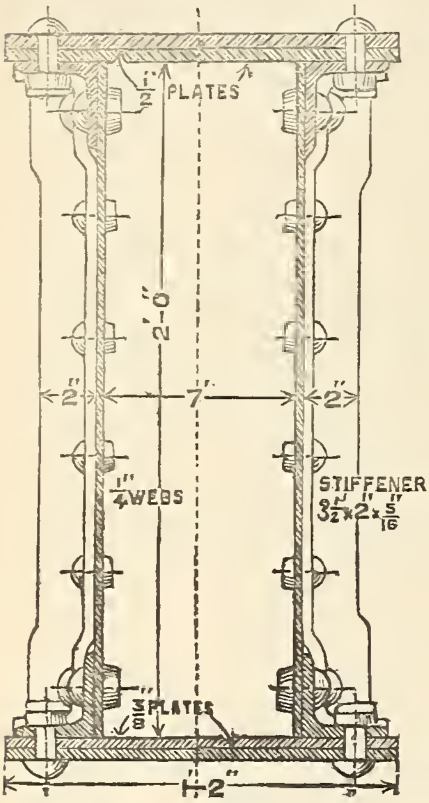


Fig. 176.

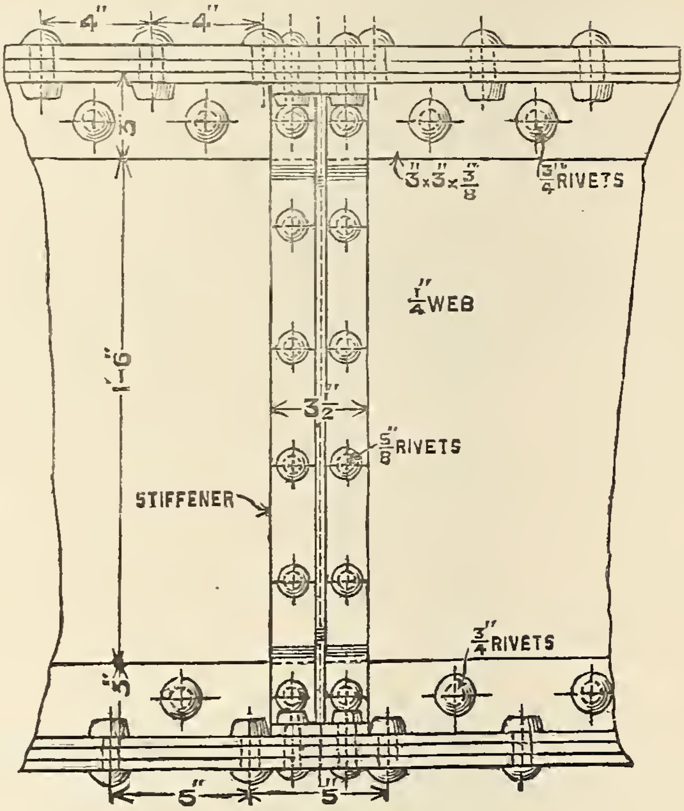


Fig. 177.

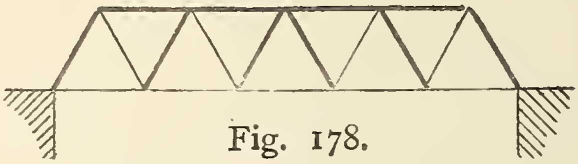


Fig. 178.

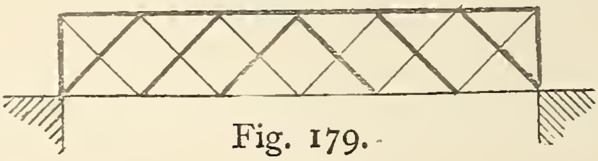


Fig. 179.

178 and 179—*i.e.*, the plate web is replaced by bars and angle irons framed together.

In these figures, when the girders are uniformly loaded on the upper flange, the thick lines indicate the members in compression, and the thin those in tension. The compressional members are termed "struts," and are usually made of angle or T irons; the tensional members are called "ties," and are of bar-iron. The vertical members joining the horizontal members sometimes used serve to transmit the load in such a manner, that one half of the load immediately above is carried by the top flange, and the other half by the lower. These vertical members are formed by angle, tee, or channel iron, according to the size of the girder. The horizontal members of braced girders are termed booms, and are constructed of plates and angle irons, in a manner similar to that of ordinary plate girders.

Iron sections framed as isosceles triangles arranged in one system and bolted or rivetted together to the form shown in figure 178, are known as Warren girders.

Figure 179 is an outline of a girder composed of two systems of triangles traversing each other, and is known as the lattice girder.

More than two systems of triangles may be arranged.

CHAPTER V.

JOINTS IN CARPENTRY.

Stress and Strain.—Stress is the name given to an external force acting upon material, and is measured in gravitation units as lbs., cwts., etc.; strain is the amount of deformation of such material, and is measured either by the perpendicular distance of the axis from its original position, or by its reduction or elongation in length.

Beams are said to be in tension when subjected to a length stretching or pulling force, as in the case of a tie-beam, and all members wholly in tension may be considered as ties.

Beams subjected to a crushing or pushing force are said to be in compression, as in a short pillar, and all members in compression may be considered as struts.

If a load or pressure be applied at right angles to the length of a beam it will cause a bending or cross strain, as when a floor joist is carrying weight. It may be noticed that the tendency of the upper part is to become hollow or concave, such fibres are in compression, and the lower in tension. Somewhere between the two will exist fibres neither in tension nor compression, and the line indicating the position of these fibres is known as the line of neutral axis, or the line of no strain, which in a perfectly elastic material would be in the centre of the section.

If a force acts with a twisting or wrenching tendency the piece strained is said to be in torsion, a strain not frequently met with in timbers of buildings, but occurring in screws and in parts of machinery.

Shearing is a cutting or sliding strain; but in woodwork, when the force shears the beam in the direction of its fibres, it is more particularly described as detrusion, as in the case of the foot of a principal rafter causing the end fibres of beam to have a tendency to slide along the grain, thus leaving shearing strain to imply that the force acts at right angles to the grain, as in the example of a loaded beam at the points of supports where the shearing stress is the greatest.

Designing Joints.—In designing joints, the following principles, based upon those suggested by Professor Rankine, should be considered:—

1. To cut the joints and arrange the fastenings so as to weaken the pieces of timber that they connect as little as possible.

2. To place each abutting surface in a joint as nearly as possible perpendicular to the pressure which it has to transmit.

3. To form and fit every pair of surfaces accurately, in order to distribute the stress uniformly, and to proportion the area of each surface to the pressure it has to bear, so that each part may be safe against injury.

4. To proportion the fastenings, so that they may be of equal strength with the pieces which they connect.

5. To place the fastenings in each piece of timber, so that there shall be sufficient resistance to the giving way of the joints by the fastenings shearing or crushing their way through the timber.

Classification of Joints.—Joints may be arranged under the following heads:—

a. Lengthening Joints.—Lapping, fishing, tabling, scarfing, building up.

b. Bearing Joints.—Notching, cogging, halving, dovetailing, housing, mortise and tenon, chase mortising, joggle, tenon, housed and dovetail tenon, tusk tenon, foxtail wedging, bridle.

c. Oblique shouldered Joint.—Mitre, birdsmouth, halving and dovetailing, oblique tenon, single abutment, bridle.

Lengthening of Beams.—Beams may be lengthened in various ways to suit the particular stress the timber has to resist. This is rendered necessary if the desired length is not obtainable in the market.

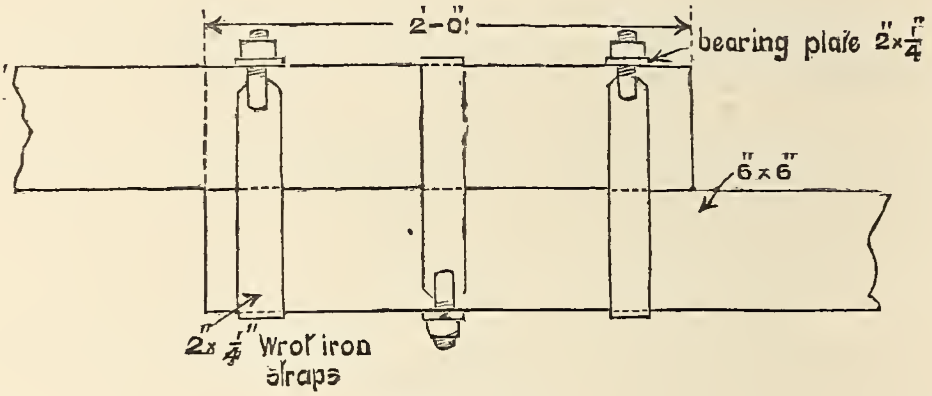


Fig. 180.

Lapping consists in resting the end of one piece on the end of another piece, and securing same with bolts if to resist tension; if compression, straps, as in figure 180, or as in scaffolding by ropes and wedges. This joint has a clumsy appearance, and should only be used for temporary structures.

Where the ends are required to be level, the length should be composed of an odd number of pieces.

Fishing.—Two pieces of timber having their ends abutting, with a plate of wood or iron secured on two parallel sides by means of bolts, are said to be fished, as in figures 181 and 182.

For the lengthening of beams, a plain fished joint is most economical for labour and material. In the event of the timbers shrinking and thus causing great stress upon the bolts, coincident grooves are cut in the pieces joined, and the fish plates and keys of hard wood or folding wedges inserted to assist the bolts, as shown in figure 184, or sometimes tabling is

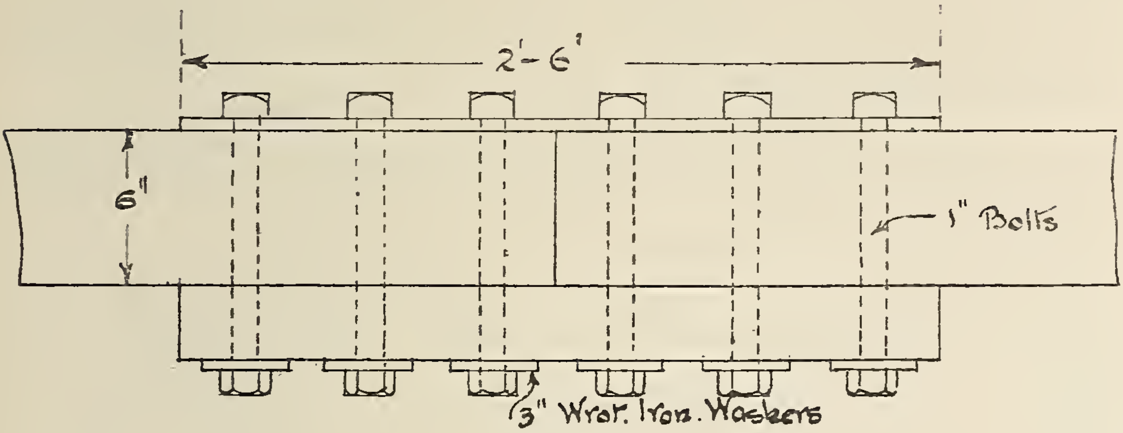


Fig. 181.

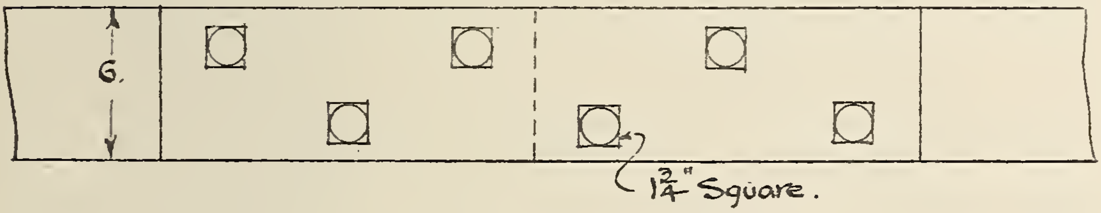


Fig. 182.

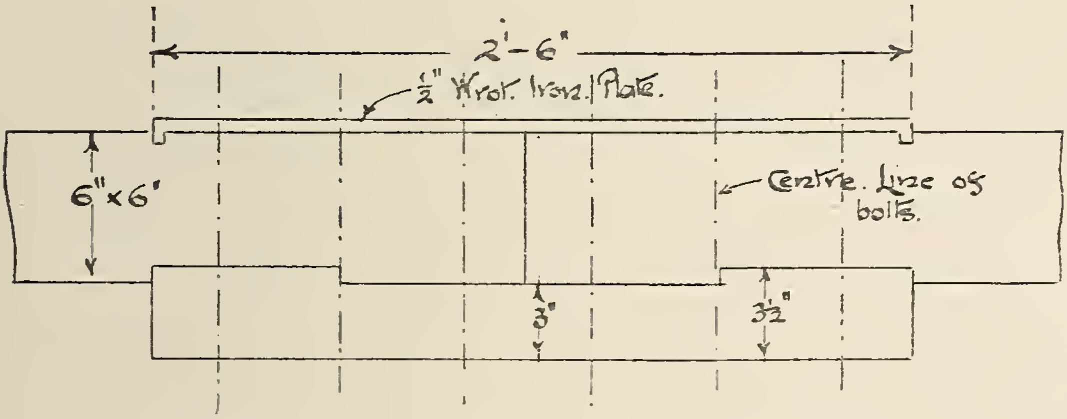


Fig. 183.

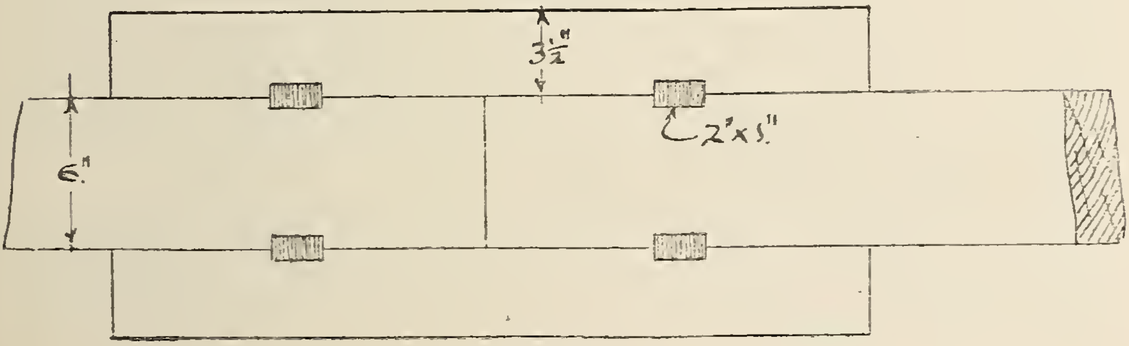


Fig. 184.

resorted to, as in figure 185, by bedding portions of one beam into another; but as this is costly and reduces the section of the beam, it is not often employed. Where iron fish plates are employed the ends are turned in. In designing a fished joint the following rules are *based* upon those given by Seddon:—

1. The strength of fished joints depends on the effective sectional area of fish-plates, together equal in tensile strength to the effective sectional area of the tie.

2. On the sectional area of the bolts on either side of the joint being sufficient to resist shearing. Let the ultimate compressile, tensile, and shearing resistances of wrought iron be taken as 36,000, 49,000, and 49,000lbs., and the ultimate compressile, tensile, and shearing resistances of good fir be taken as 5,000, 4,000, and 600lbs., respectively per square inch of area opposed to force, then the shearing strength of wrought iron is to the tensile strength of fir as 49 is to 4, or approximately 12 to 1, therefore the shearing area of the wrought iron should be one-twelfth the net tensile area of beams joined, that is, in members connected by a fished joint, subjected to single shear with one plate only, the sum of the sectional area of the bolts on each side of the joint should equal one-twelfth the net tensile area of the timber joined; with fished joints with two plates (the usual practice), this being subjected to double shear, the sum of the areas of the sections of the bolts on each side of the joint should equal one twenty-fourth the net tensile area of the timber joined. Generally, in any joint connected by bolts, the number required may be ascertained by making the sum of the minimum sectional areas opposed to the shearing force, which on shearing would cause failure of joint, to equal in area one-twelfth the net tensile area of the timber.

3. On the placing of the bolts in such a way and at such distances from the ends of the timbers, as to prevent their drawing through them.

4. The bearing area of the bolts must be sufficient to prevent their cutting their way through either the timbers or the fish plates.

Scarfing and Fishing.—The following difference may be noticed between a fished and a scarfed joint.

In the fished joint the total length of pieces joined is not reduced, while in the scarfed joint the pieces are cut and fitted over each other so as to keep the same breadth and thickness throughout, the total length of pieces joined only being less than the sum of the separate lengths.

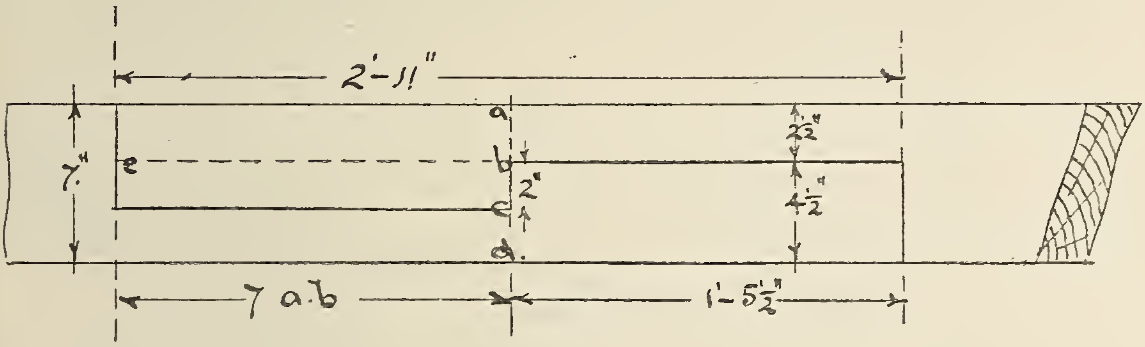


Fig. 185.

Scarfing should be used for the jointing of timber in the direction of its length if neatness be necessary as well as strength.

Figure 185 shows a tabled joint, and if this be calculated as shown, dimensions for other scarfs may be reasoned out in a similar manner.

If area expressed by $b\ c$ yields, the joint fails under compression; should $a\ b$ or $c\ d$ rupture, the joint fails under tension. By equating, it will be found for fir compressional area required is four, when the tensile area is five.

$$\therefore b\ c = \text{compressile area} = \tfrac{4}{14} \text{ depth of beam.}$$
$$a\ b = c\ d = \text{tensile area} = \tfrac{5}{14} \text{ depth of beam.}$$

$b\ c$ is the area opposed to detrusion for fir; by equating, it will be seen that the necessary area will be $\frac{40}{6}$ of the tensile area, or approximately the detrusion area must be seven times the tensile area.

The lengths of scarfs may then bear the following proportion to depth :—

Length $= 14 \times \frac{5}{14} = 5$ times depth $\left\{\begin{array}{l}\text{Without the assistance of}\\ \text{iron bolts.}\end{array}\right.$

When the scarf is assisted by bolts and fish plates the strength of the joint may be made equal to the strength of the net tensile area of the timber; that is, if there are two lines of bolts in the plan the sectional area will be reduced by the sum of the sectional area of fibres cut by two bolts. The length of the scarf may vary between three times the depth and zero times the depth, in which latter case it practically becomes an ordinary fished joint.

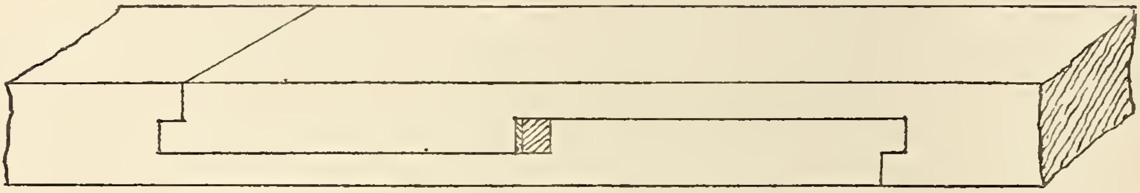


Fig. 186.

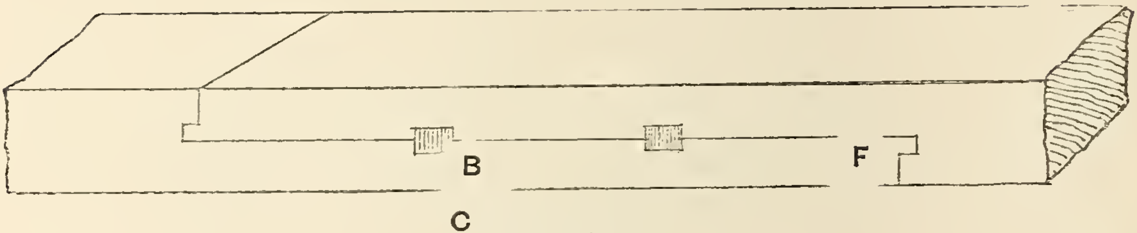


Fig. 187.

Figures 186 and 187 show two forms of joints to resist tensional stress. Figure 186 shows a scarf constructed by tabling, tongued at ends, and secured by hard wood keys and wedges. Figure 187 shows a simple form of scarf made by halving, tongueing, and tightened up by wedged keys. The shearing area along BF to be at least seven times BC, and BC should equal $\frac{5}{4}$ times the sum of the depths of the keys.

Figure 188 shows the form of scarf which, assisted by bolts and fish plates, is most commonly used in practice to resist tensional stress, the simplicity, easiness of fitting and putting together by means of oak wedges render it a suitable and efficient joint for the purpose, the resistance to the shearing stress being offered by the wrought-iron bolts.

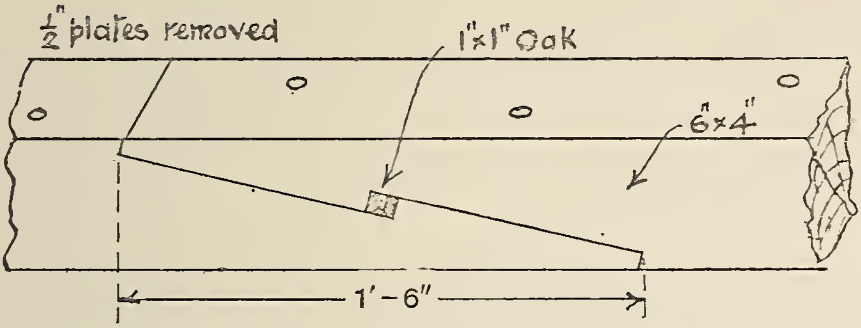


Fig. 188.

Scarfs to Resist Compression.—For joints to resist compression the abutting surfaces should be perpendicular to the pressure, consequently, all shoulders should be square, and no splayed sallys or internal angles should be allowed. The following are suitable :—Scarfs similar to those shown in figures 186 and 187. The method shown in figure 189, formed by halving, iron plates and bolts, is the simplest and most effective if plates and bolts are permissible.

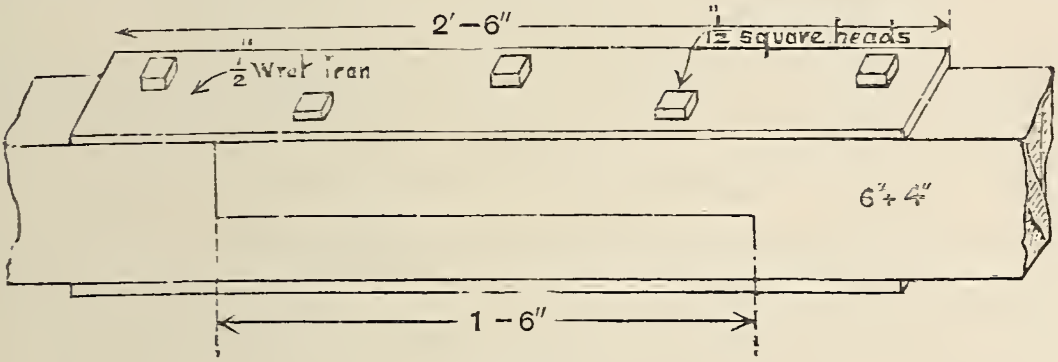


Fig. 189.

Transverse Stress.—Wherever the span to be bridged is too great to admit of the use of timber in one piece, the beam employed should be trussed, so that every member might be under a direct length stress, as the joints that have been designed, although ingenious and costly, are not satisfactory.

Building up.—Curved ribs of domes, roofs and centres, as shown in advanced book, standards of derrick crane towers, as shown in advanced book, and booms of trussed timber girders may be economically built up as shown in elevation and plan, figures 190 and 191.

The strength of such a rib may be considered equal to a solid rib with an equal depth, but of a thickness equal to the sum of the thicknesses of the separate pieces minus one.

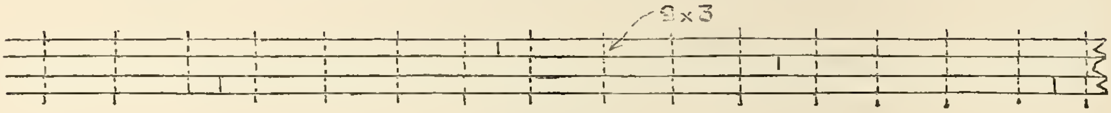


Fig. 190.

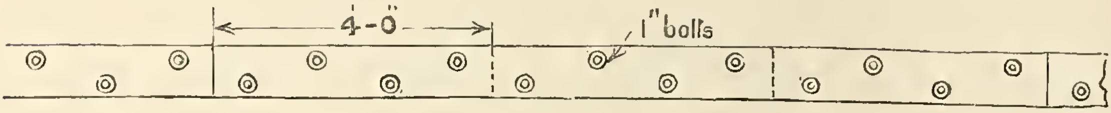


Fig. 191.

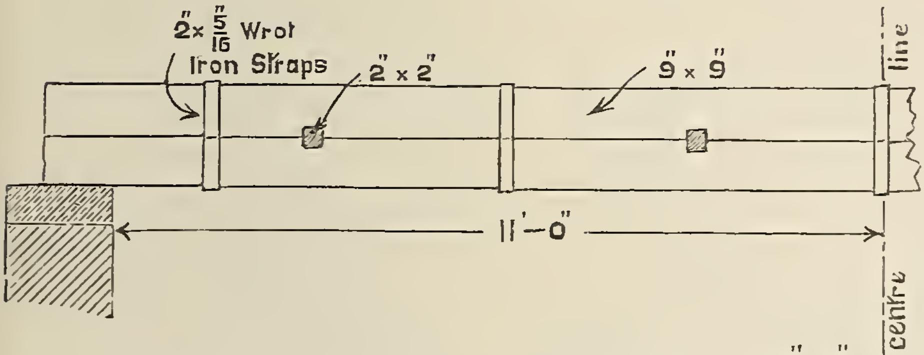
Figure 192 shows another method of building, by placing one timber directly on the other, to obtain a deeper beam that could be readily obtainable in one piece. To resist the horizontal shearing stress, hard-wood keys with the grain at right angles to the stress are inserted. The timbers are held together by iron collars or straps bolted as shown in fig. 192.

Another method of obtaining the same result is by forming the joint between the two members by a series of indents, and joining by iron collars or straps, bolted, taking care to arrange the shoulders of the indents, as shown in figure 188, to resist the compressional stress caused by the upper piece tending to slide over the lower.

Notching.—Joists resting on wall plates are commonly notched, as shown in figures 194 and 195, for the purpose of bringing all the upper surfaces to a required level, the shoulders assisting in forming a fixing and in keeping the work square. The plate should be notched in the case of joists, as shown in figure 198, to obtain a bearing for the whole depth of the joists.

Cogging.—When wall plates, purlins, rafters, or other timbers have timbers crossing them and it is desired to have the entire bearing depth of timber, and to tie the lower, other than by the fastenings which often consist only of spikes, the pieces may be cut and fitted as in figure 197, two cheeks of rectangular section being taken out of lower piece, and the upper member having a sinking to correspond to the projection left on lower piece; this method is called cogging. Where the end of the joist does not project over plate it is advisable to form the cog nearer the edge of plate, as in figure 196, to obtain the greatest amount of shearing area behind the cog, as the section of bearing surface has usually an excess of strength.

Fig. 192.



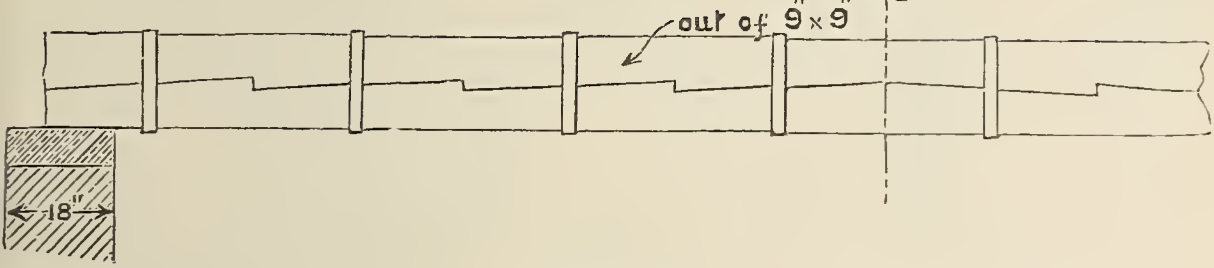


Fig. 193.

Halving.—Timbers that cross each other, and are required to be flush on one or two faces, and have a similar sinking in both to fit each other, are said to be halved together, and may be cut as ordinary bevelled or dovetailed halving.

1st. Ordinary halving, as in figures 199 and 200, suitable for wall plates or braces of partitions crossing each other.

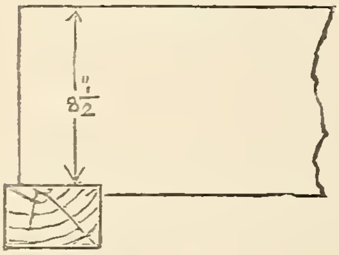


Fig. 194.

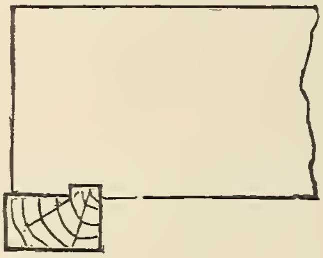


Fig. 196.

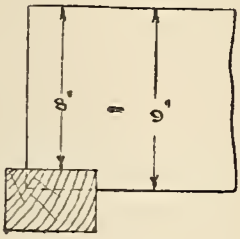


Fig. 198.

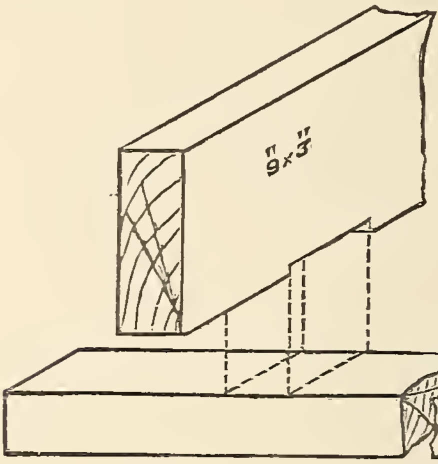


Fig. 195.

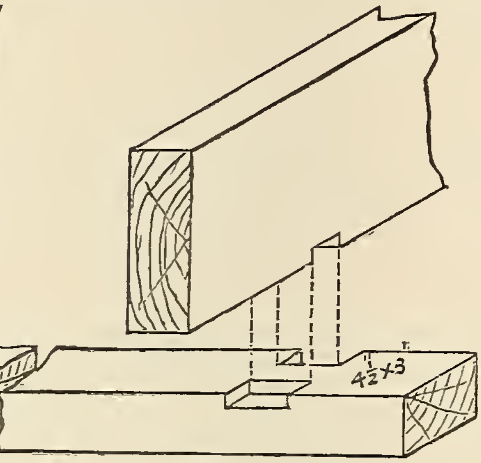


Fig. 197.

2nd. Bevelled halving, which assists in holding pieces together when spiked, as shown in figures 201 and 202.

3rd. Dovetailed halving is used where one member is to act as a tie for wall plates, as in figure 203; but as the dovetails are usually made of great width in carpentry the pieces shrink, and the joint becomes loose, and fails for the purpose for which it was intended.

Dovetailing.—The joints of the angles of such timbers as curbs, pole plates, etc., which are usually deeper than the ordinary wall plate, are dovetailed as shown in figure 204.

Housing.—When the entire end of a piece of timber butts and fits into another piece, it is said to be housed, and is used for heavy work, or where other methods would be weak or

Fig. 199.

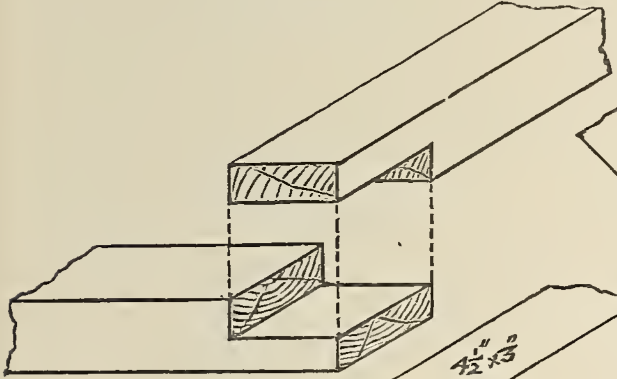
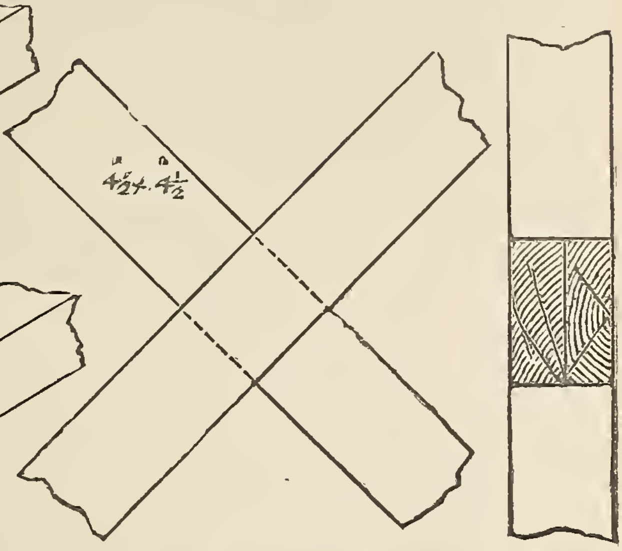


Fig. 200.



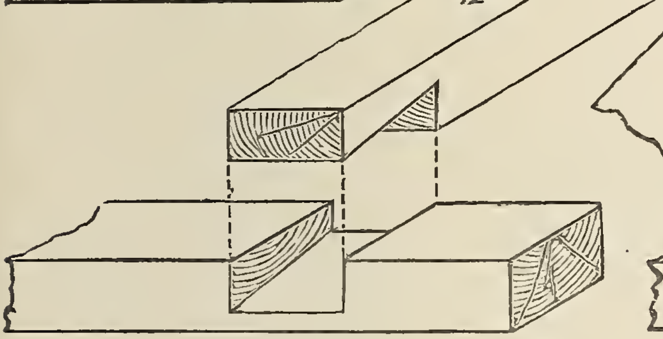


Fig. 201.

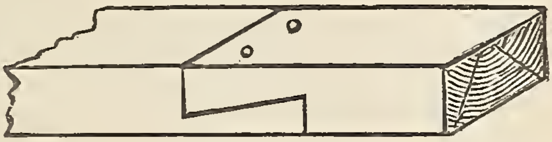


Fig. 202.

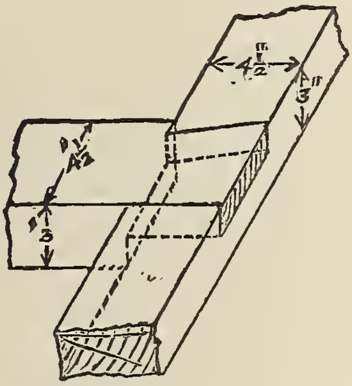


Fig. 203.

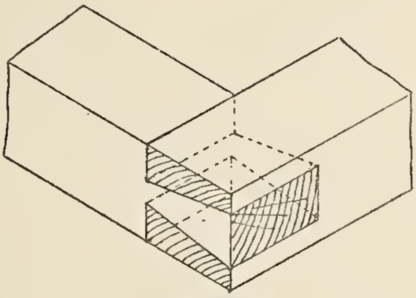


Fig. 204.

expensive. The pieces joined would be secured by bolts, straps, wedges, or other fastenings.

Mortise and Tenon.—For simplicity of construction and efficiency for its purpose, the mortise and tenon joint is pre-eminently good; and is, undoubtedly, used in some form or other more than any other kind of joint.

Ordinary Mortise and Tenons.—The end of a piece of timber is cut so that a projection or tenon is formed which has a thickness ⅓ that of the material; the adjoining piece is mortised to correspond to the tenon, and may be secured either by wedges from the back, as in figure 205, by dowel pins from the faces, as in figure 409, or wedges and dowels may be combined for purposes of strength.

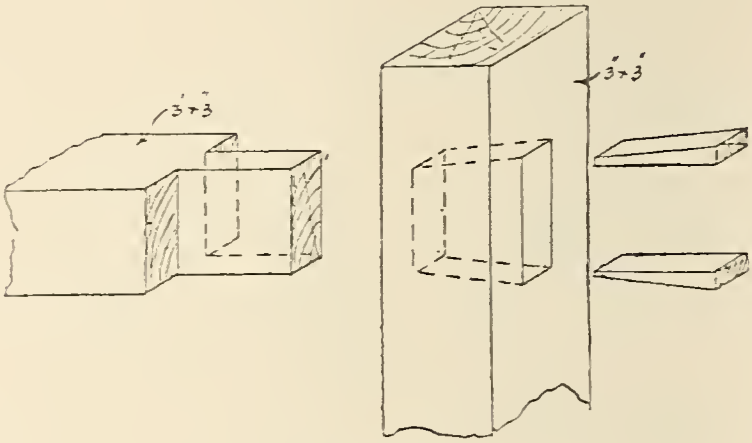


Fig. 205.

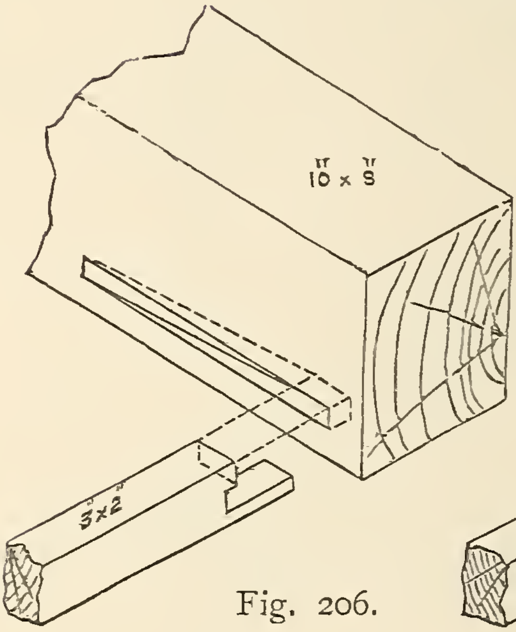


Fig. 206.

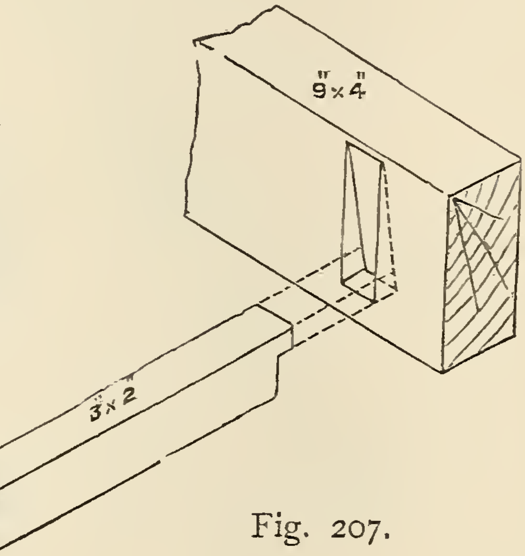


Fig. 207.

Chase Mortises.—Wherever it is required to fix timbers between the main timbers which are already secured and immovable, the method of chase mortising may be adopted, which consists in fitting one end in the ordinary manner, and in the other main timber the mortise to receive the other extremity is cut, as illustrated in figure 206, to allow the tenoned member to revolve into its ultimate position, the end fitting into the ordinary mortised main timber, being used as centre. The same purpose may be accomplished by cutting a vertical groove, as in figure 207, to allow the tenoned member to drop into its place; but by this method fibres are cut, which are not necessarily severed for the mortise, and so its strength is reduced. The better system is to make the horizontal chase, which has the advantage of not unnecessarily reducing its tensile strength. Ceiling joists in double and double framed floors are very extensively fixed in this manner, and instead of cutting away a triangular piece for each joist, a rectangular groove in plan is cut between mortises in every other space between the joists.

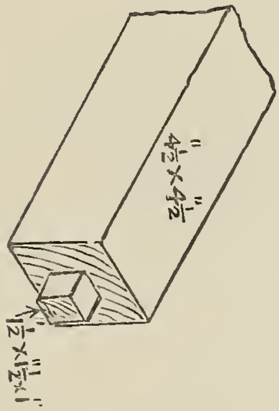


Fig. 208.

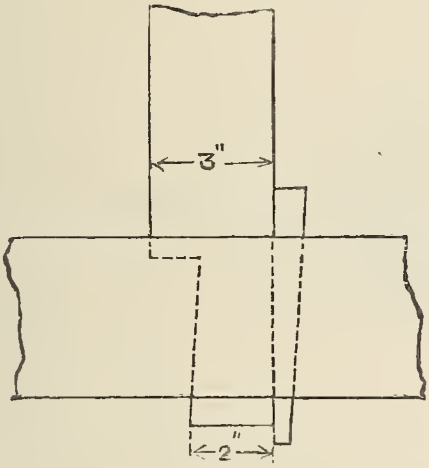


Fig. 209.

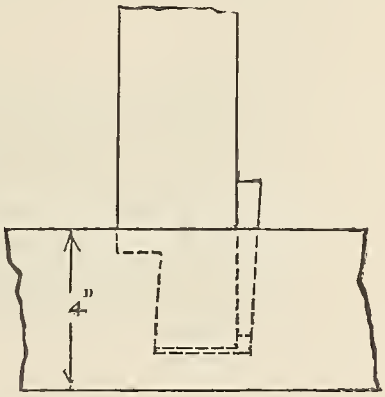


Fig. 210.

Joggle, Stub, or Stub Tenon is the name given to a short tenon, and is more particularly known as a joggle when cut, as shown in figure 208, which is used to prevent the foot of a post sliding away from its sill.

Tenoned and Housed Joints.—For purposes of bearing strength where the ordinary tenon might not be sufficient, the rail is housed a short distance into the post or style, and tenoned in the usual manner. Figure 276 shows this joint, and the shoulders pulled closely together by means of a key.

Dove-tailed Tenon.—Where two pieces are required to be held together by a mortise and tenon, and to be taken apart occasionally, the tenon may be cut dovetail shape and the mortise made long enough to permit the wide part of tenon passing through, and when in this position it is secured by a hard wood wedge, as in figure 209. This method may be adapted to secure pieces together, as shown in figure 210, when the back edge is not to be cut or is inaccessible.

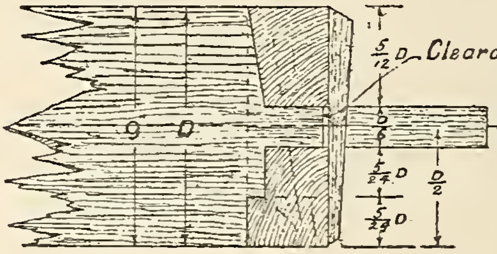


Fig. 211.

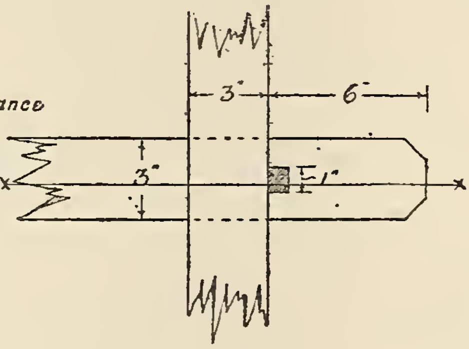


Fig. 212.

Tusk Tenon.—Where floor timbers of equal depth are framed into each other it is desirable that the loss of strength should be reduced as much as possible, and yet the members joined must be securely held together. The best bearing joint complying with these conditions is the tusk-tenoned joint. The tenon should be placed in the centre of the depth of the pieces joined for two reasons. First, when it is in that position the stress caused by driving the wedge draws up both top and bottom shoulders equally tight. Secondly, the best position for the mortise is theoretically in the compressional fibres immediately adjoining the neutral layer, and in good specimens of northern pine timber beams, supported at both ends under loads, this layer is three-eighths of the depth from the bottom, and consequently five-eighths of the depth from the top; this is due to the resistance of compressional to tensional stress being in good quality fir or pine timber, in the ratio of three to five, and thus causing the neutral layer in a rectangular beam to be in the position stated, but as any knots or defects in timber would affect the tensional fibres more than the compressional, it is safer to place the centre of the tenon in the centre of the depth, which will be found in practice quite sufficient, and to make the tenon $\frac{\text{depth}}{6}$. The underside of the tenon will then be $\frac{D}{24}$ above the theoretical neutral layer of a good specimen, and most probably exactly above in an average quality timber. The depth of the tusk may be $\frac{5}{24}$D of the depth, that is, one half of the distance between the under surfaces of tenon and joist, as shown in figure 211.

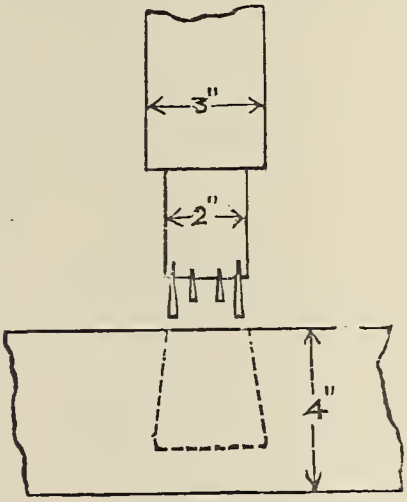


Fig. 213.

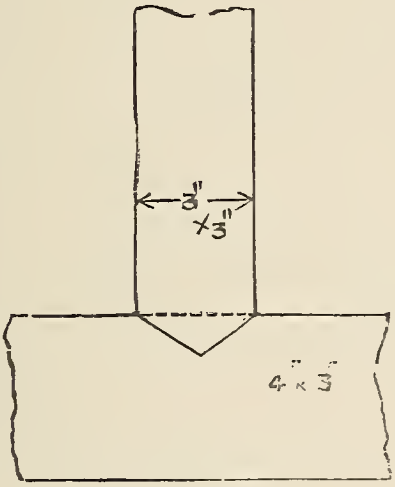


Fig. 214.

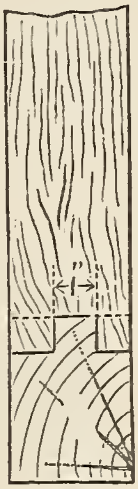


Fig. 215.

In cases similar to binders tusk tenoned to large girders, especially wherever the tenons of two binders are arranged exactly opposite, the tenons of the former do not pass through the entire section of the latter, but only penetrate

3 or 4 inches, and are then spiked with large iron nails or secured with oak dowel pins or trenails, always aiming to reduce the section of the main timber as little as possible, as shown in figure 260.

Foxtail Wedging is a method of securing timbers, as shown in figure 213, where the back edge of the mortised member is inaccessible. It is mostly used in joinery work for securing the parts of framing as in the rails and styles of doors in high class work, in which the end grain of the tenon would be unsightly.

The mortise is sunk to from ½″ to 1″ of the back of the mortised member and is made slightly dovetailed in form. The tenon is neatly fitted, two saw cuts are made, one at each side of the tenon, about $\frac{3}{16}$″ from the side. Into each of these a wedge is inserted; when the whole is ready, the tenon is glued and forced home. During this operation the wedges are urged into the saw cuts, causing the end of the tenon to spread and fill the dove-tailed mortise.

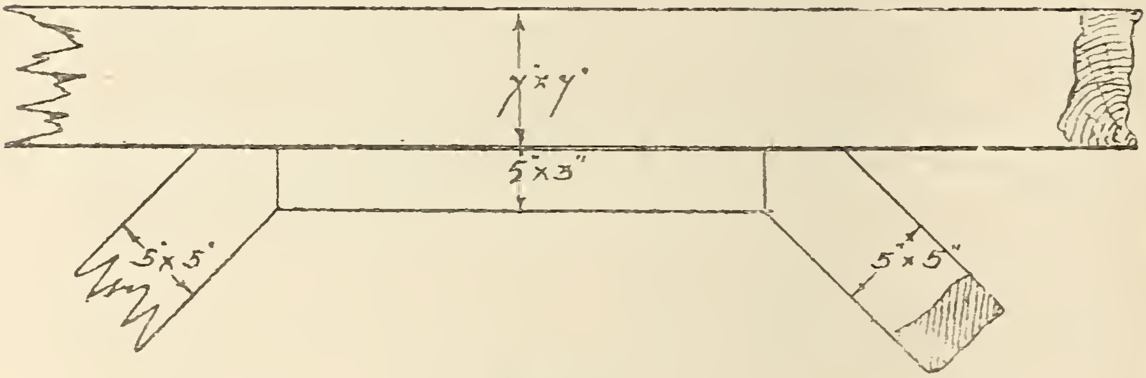


Fig. 216.

Bridle Joint is the name given to that joint, as shown in figures 214 and 215, that has its mortise or slot on the member that would be tenoned in the ordinary method, and the piece on which a sunk tenon is formed would in the usual joint be mortised. It is more expensive to make, but some architects prefer it to the mortise and tenon joint, as any bad workmanship can be easily detected.

Strut and Beam Joints.—Where struts are used to strengthen horizontal beams or shores, a straining piece is usually fixed to the beam, and the ends of the struts cut as shown in figure 216. Where the horizontal member is short the straining piece is dispensed with and the ends of the struts are butted.

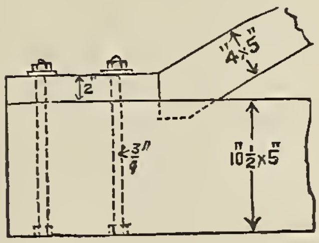


Fig. 217.

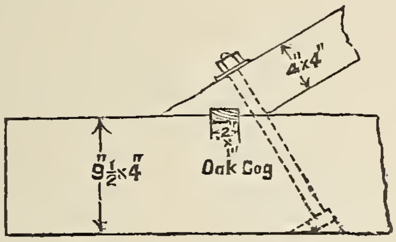


Fig. 218.

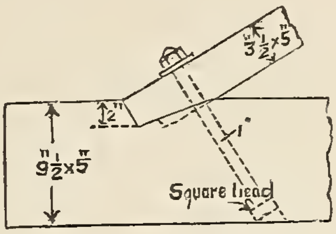


Fig. 219.

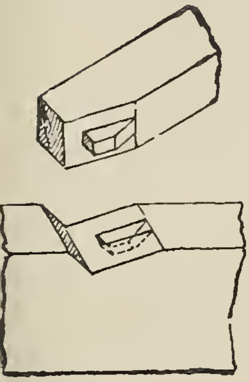


Fig. 220.

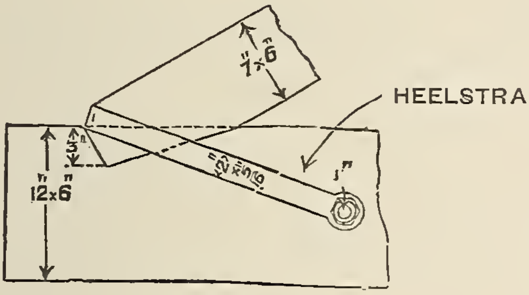


Fig. 221.

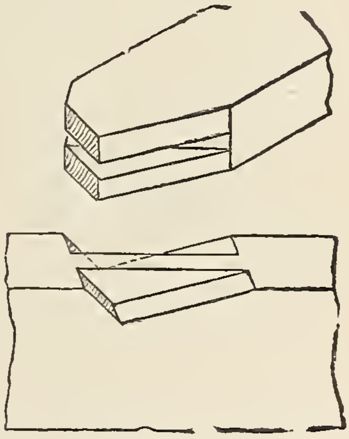


Fig. 222.

Joints for Struts and Ties.—These may be constructed as follows:—

(*a*). With oblique tenons which would be liable to shear, or assisted by plate bolted to tie, as shown in figure 217.

(*b*). By inserting a piece in grooves cut in rafter and tie beam, to prevent sliding, as in figure 218.

(*c*). With single abutment and tenon, as shown in figures 219 and 220. This is simple, effective, and generally used when there is sufficient length of tie behind strut to resist shearing stress.

(*d*). *Bridle Joint.*—This is a method employed to increase the shearing area; it is especially applicable to such work as shown in figures 221 and 222, where the length of tie in front of strut to resist the thrust is small. In addition to having a large shearing area, it has the advantage that any defect in the fitting would be apparent.

Fastenings.—Joints in carpentry should have white-lead applied with a brush over the surface forming the joint, and may be secured in their positions by the following fastenings :—

1. Pins
   - Wood Pins.
   - Nails.
   - Bolts.
2. Wedges.
3. Straps.
4. Sockets.

Pins.—These may be of wood or iron, and may be subdivided as dowel pins, trenails, spikes, dogs, screws, and bolts.

Dowel Pins.—When boards are required to be kept in the same plane surfaces, and yet not to resist the shrinkage of the wood, dowels out of oak or hard wood of straight grain and split to the diameter required, and not cut with the saw, so that none of the fibres are cut across, and slightly tapering in their length, are employed as in the example of flooring, figures 240 and 241. Dowels are used to fix mortise and tenon joints, and are especially applicable for large or triangular framing to pull the shoulders tightly up, which method is called drawboring, which consists of boring through mortised piece, then marking tenoned member and boring same, not exactly in the mark, but towards outside corner of shoulder, which has the effect, when the dowel is driven with great force, of bringing shoulder up closely.

Trenails.—Hard wood pins of large diameter are called trenails, and are extensively used in shipbuilding or in positions where iron fastenings would be liable to rust.

Spikes are iron nails above three inches in length, extensively used in fixing timbers together. They require to be hammered in with great force. Spiking is a cheap method of fixing.

Screws.—These are used instead of nails where any vibration in fixing would be objectionable, or where pieces are required to be taken apart occasionally, as in figure 432.

Bolts.—Wrot iron bolts and coach screws are used where spikes or screws would not offer sufficient tensile resistance. The bolts are screwed at one end for a tapped nut to fit on, and to prevent nut and head sinking into timber when tightened up, are supplied with wrought-iron washers, which, against oak, should be two and a half times diameter of bolt, and for fir, three and a half times.

The ratios of the dimensions of the head of a hexagonal headed bolt and nut and square headed bolts and nuts in terms of the diameter of the shank are given in the Chapter on Iron Roofs.

Dogs are pieces of flat or round wrought iron bent at ends, which are pointed and hammered in to secure timbers that butt against each other, especially used in shoring, rough stagings, and temporary structures.

Wedges are pieces of wood cut taper to secure joints together, as in the mortise and tenon joint; when used in pairs, as for scarfs which draw up more equally, are called folding wedges.

Keys is the name given to hard-wood wedges, especially used to pull joints closely together, as in tusk-tenon joint, figure 211.

Straps are fastenings formed of metal bands, usually wrot iron, to enclose timbers together and keep them in the required positions, and may have ends forged and screwed which pass through bearing-plates, to which they are secured, or may be drawn up by gibs and cotters, as illustrated in figures 287 and 288, or may simply form a stirrup or heel-strap, and be secured by a bolt, as in figure 221, where it is used to prevent the end of the tie-beam being sheared.

The advantage of straps over bolts is that they need not cut into the timbers joined.

Tredgold's rules for straps are as follows :—

10	ft. span the strap may be	1	in. wide by	$\frac{3}{16}$ths	in. thick.
15	,, ,, ,, ,,	$1\frac{1}{2}$	,, ,,	$\frac{1}{4}$	,,
20	,, ,, ,, ,,	2	,, ,,	$\frac{1}{4}$	,,

Sockets are made of cast iron to enclose the ends of timbers to prevent it splitting, and to retain the pieces in the required position, as in figure 299. When used at the feet of members they are called shoes, as in figures 297 and 298.

CHAPTER VI.

FLOORS.

Definition.—The tiers or levels which divide a building into stages or stories are called floors.

Classification.—Floors for residential purposes are mostly made of timber, and may be divided under three heads—

Single-joisted Floors include bridging joists.

Double-joisted Floors include bridging joists supported by binders.

Framed Floors include bridging joists supported by binders, the latter usually being framed into girders which finally support the load.

Single Floors.—When the total weight upon a floor is carried by a single system of joists, which span or bridge an opening, it is called a single floor, and the joists are known as bridging joists, and are usually fixed twelve inches to fifteen inches apart between the centres; and although the simplest construction, with the same quantity of timber it forms the strongest floor. To these joists laths may be nailed to receive the plaster, or ceiling joists are attached, crossing at right angles the bridging joists, to which the lath and plaster is attached. It is usual to arrange the bridging joists in the direction that has the least span between supports.

Material.—In England, timber joists, binders and girders are usually of northern pine, often known as Scotch fir or yellow deal. It is to be preferred before white fir or spruce, as it resists greater transverse bearing stresses, is more durable, and the difference of cost is slight. For works where great strength is required, as in wood floors of large spans for public buildings, pitch pine is commonly used.

Scantling for bridging joists of northern pine, distance apart from centre to centre twelve inches.—From Tredgold's "Carpentry":—

Clear span in ft.	Dimensions in inches.	Clear span in ft.	Dimensions in inches.
5	5¼ × 2 or 4⅜ × 3	14	10 × 2 or 9 × 3
6	5¾ × 2 ,, 5 × 3	16	11 × 2 ,, 9¾ × 3
8	7 × 2 ,, 6¼ × 3	18	12 × 2 ,, 10½ × 3
10	8 × 2 ,, 7 × 3	20	12 × 2½ ,, 11 × 3¼
12	9½ × 2 ,, 8 × 3		

Basement Floors.—Under the basement floors of houses thin walls are built generally about 6 feet apart to carry sleeper plates, to which the joists are fixed. The nearer the sleeper walls are constructed, the less will be the scantling of joists required. Figure 223 gives a section through a sleeper wall.

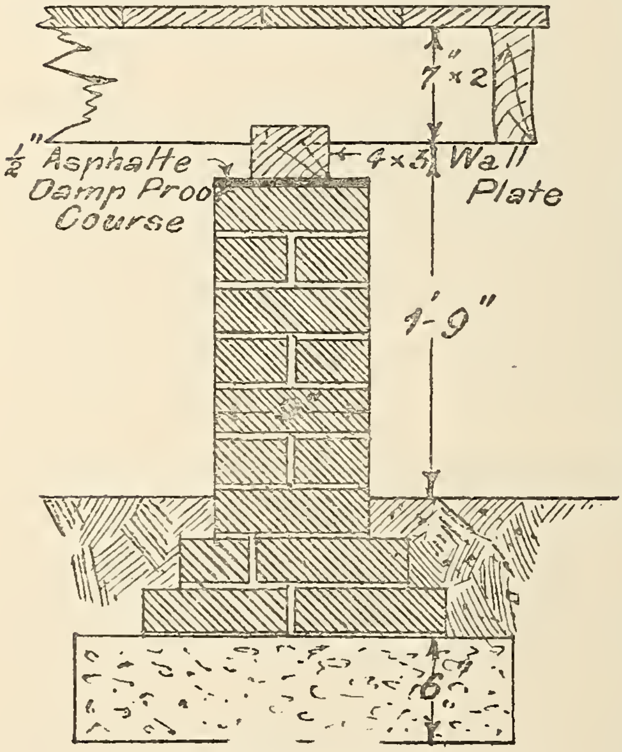


Fig. 223.

Upper Floors.—Floors above the basement are constructed with trimmed openings to form well holes for staircases, lifts, trapdoors, and to clear flues, in order to satisfy the model byelaws, which require that no woodwork may penetrate walls nearer than 9 inches to the flue, and no wall plate or joist

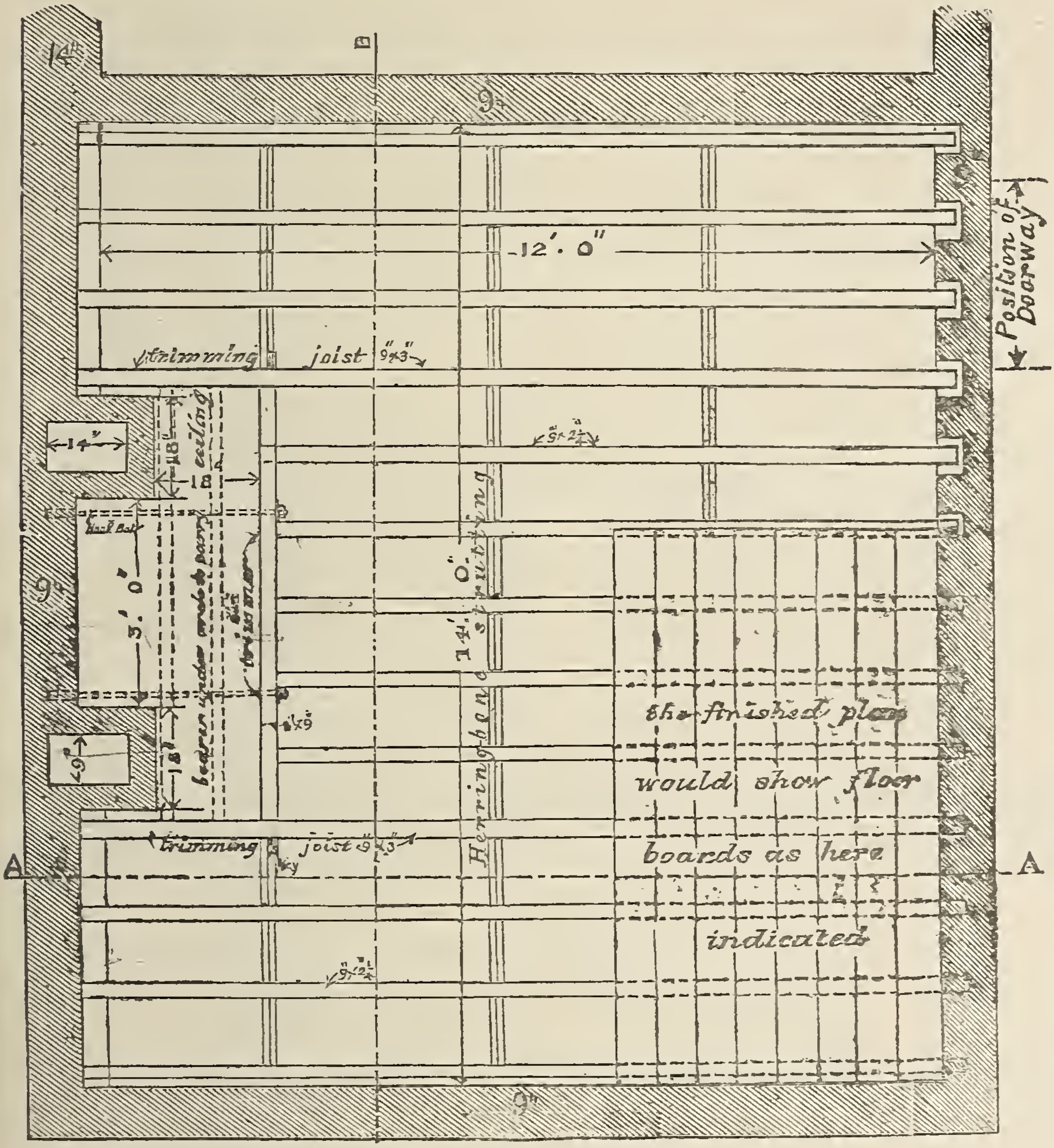


Fig. 224.

may be within a distance of 2 inches from a flue wall less than 9 inches thick without it is rendered in cement.

Figure 224 shows the trimming to clear flues in chimney breasts, the joists being arranged in the shortest direction; this necessitates two trimming joists and one trimmer, which is carrying the ends of five trimmed joists. All the joints between trimmed, trimmer, and trimming joists are tusk tenoned, as described on page 88, to have great bearing strength. To obtain 18 inches of fireproof material, 7 inches thick, in front of fireplace, a coach head trimmer arch is turned, as shown in figure 227, which may extend from trimming joist to trimming joist, and never less than 9 inches on each breast, over which is a bedding of concrete, and back and front hearths of York stone 2½ inches thick. Sometimes back and front hearths are in one piece, and are usually 18 inches longer than openings. The floor is stiffened with herring-bone strutting, the rows of which should not be more than 4 feet apart.

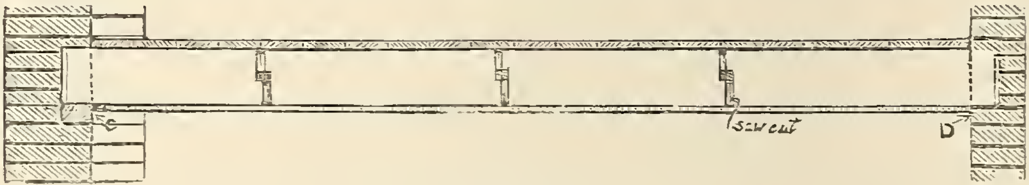


Fig. 225.

Section through Fireplace.—Figure 227 gives section which shows method of forming rough coach head trimmer arch, with wood springing piece nailed to trimmer. The ceiling underneath is upheld by small joists resting on fillets 1½ inches by ¾ inch, nailed to trimming joists; or the ribs used as the temporary centre of the arch are allowed to remain to answer that purpose.

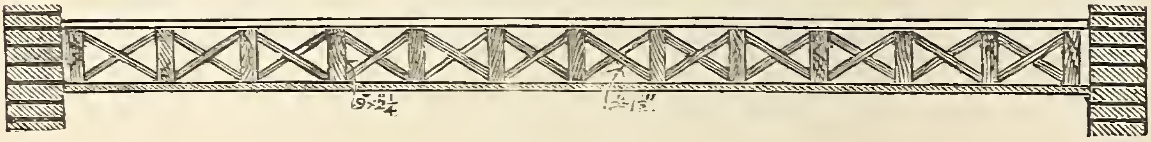
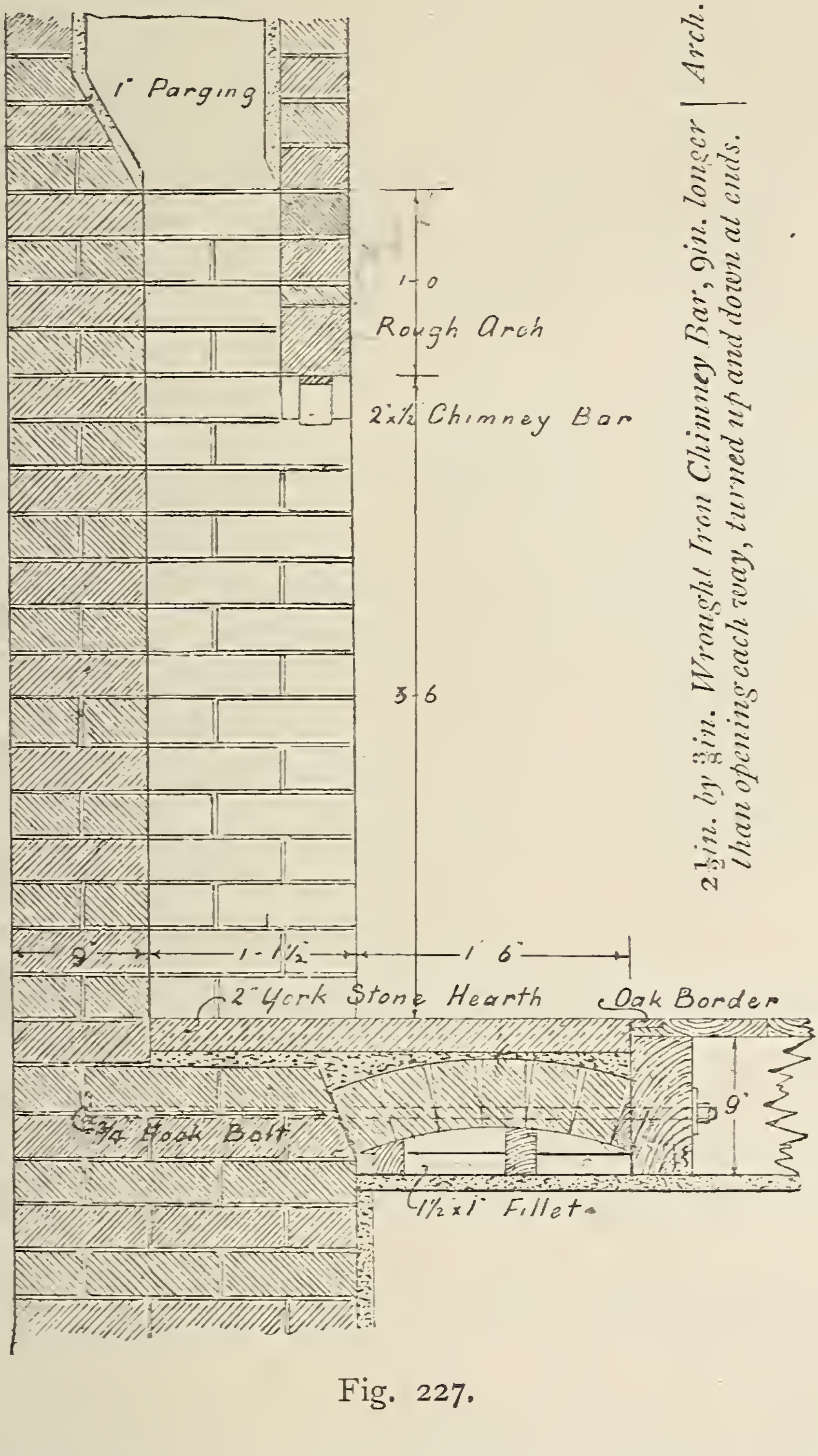


Fig. 226.

In wide chimney breasts the arch is sometimes stopped before it reaches the trimming joists, and a shaped piece of joist timber may be bedded on the back of the arch, provided it is 9 inches away from opening, to which the floor boards are secured. Sometimes a short joist is placed against end of arch, tusk tenoned into trimmer, the other end resting on an iron bar or corbel which is fixed into the brickwork.



2½in. by ⅜in. Wrought Iron Chimney Bar, 9in. longer than opening each way, turned up and down at ends. | Arch.

Fig. 227.

Where the plan of a floor shows a trimming joist instead of trimmer forming abutment of arch, as in figure 228, two hook bolts should be used between the flues, to prevent the arch failing by the trimming joist bending, as shown by dotted lines, figures 227 and 228.

Figure 228 gives the outline plan of floor arranged with bridging joists laid in the shortest direction, and as flues are in the same direction there will be only one trimming joist, and that parallel to the width of chimney opening, and two short trimmers carrying the trimmed joists.

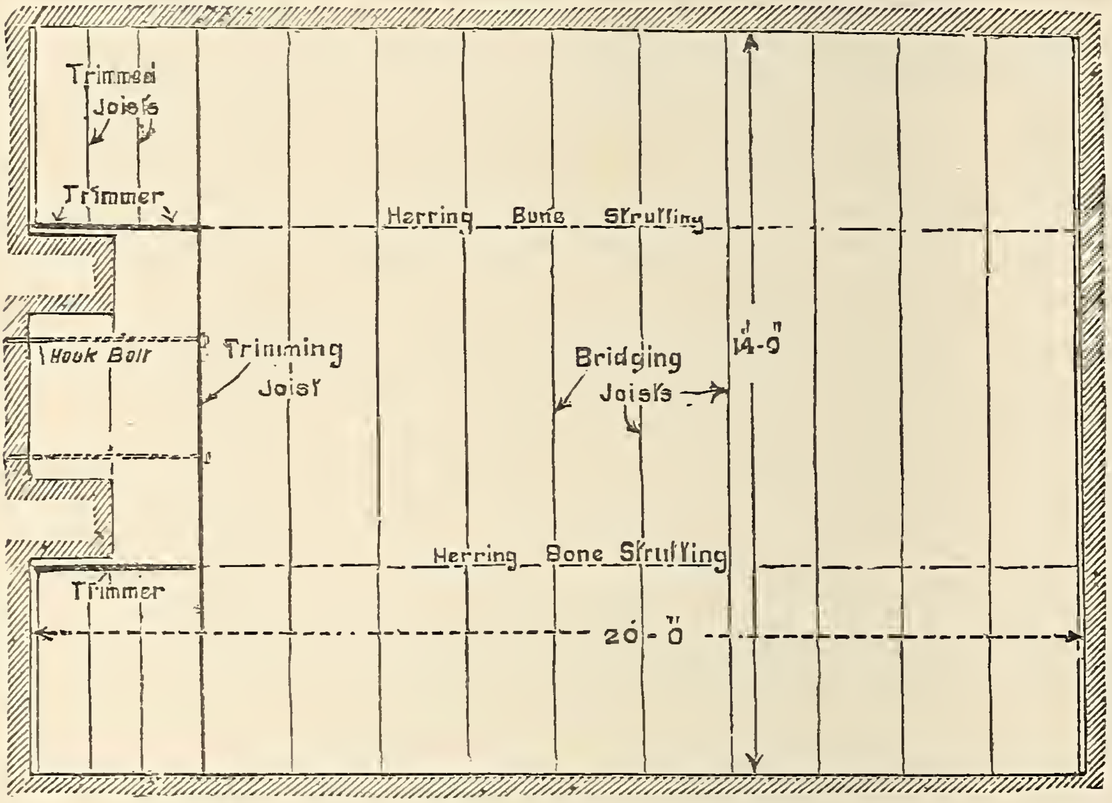


Fig. 228.

This method requires less timber and labour than those laid in the opposite direction, as shown in figure 224.

Bearing of Joists.—The model bye-laws state that no timber must be built in party walls nearer than $4\frac{1}{2}''$ to the centre plane of the wall.

There are various methods adopted for resting or fixing the ends of the joists upon walls.

1st. The joists are often built into walls and bear directly upon the brickwork, but this is objectionable as the weight is not thoroughly distributed over the wall, and the ends of the timber are subjected to dry rot.

2nd. Wall plates are sometimes built into walls. If so fixed they are subject to the same objection as bond timbers, and should therefore not be employed.

3rd. The best method is to build in a wrought iron bearing bar (2″ by ⅜″) upon which the joists rest, as shown in figure 232. This distributes the pressure and is not open to the disadvantages of a plate. Pockets are formed in the brickwork allowing the timber at least ½ an inch clearance about end of joist, to allow for the circulation of air.

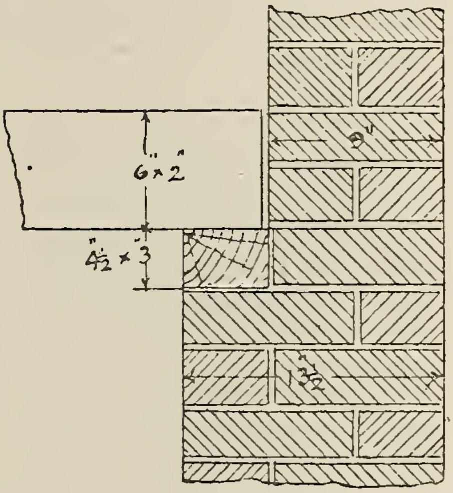


Fig. 229.

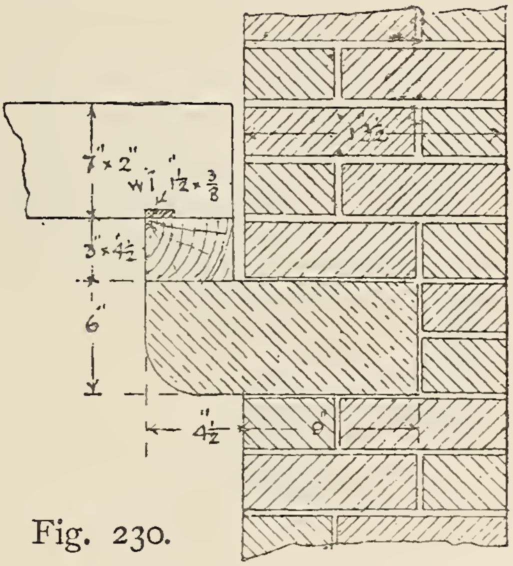


Fig. 230.

4th. The joists may simply rest upon and be spiked to a wall plate which receives its bearing from a set-off or projection of the wall, as is usual at the lowest floor and at other heights of walls where the thickness is diminished by half a brick. This is a very good arrangement, as the wall plate then fulfils its function of distributing the pressure of the floor without reducing the section of the brickwork, as shown in figure 229.

5th. The method of corbelling is adopted for thin walls to take the bearing of joists. Figure 230 shows a wall plate supported by a stone corbel. It is better if the corbels be formed of two courses of bricks each set off 2¼″, as stone is not to be relied upon when subjected to fire and water. The best corbels to support the wall plate are made of wrought iron (as shown in fig. 231), 4 inches wide and ½ or ¾ inches thick, bent at the ends as shown and built into the walls about 3 feet apart. They should be let in the wall 9 inches with sufficient weight above, which should always be noted, and care must be taken that they rest upon good hard bricks or stone to prevent crushing at the edge.

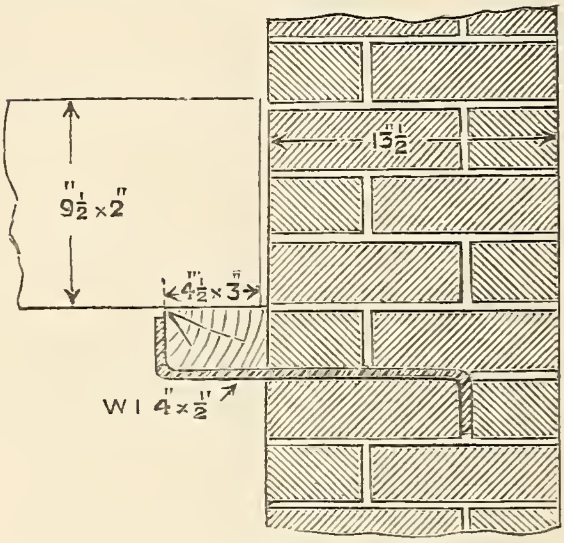


Fig. 231.

Bearing Joint. — Joists may simply rest upon wall plates or binders, the lower surface of joist resting upon the upper surface of binder or plate, and fixed by being nailed; by this method the full depth of the joist is obtained, which is the chief point, with the least labour.

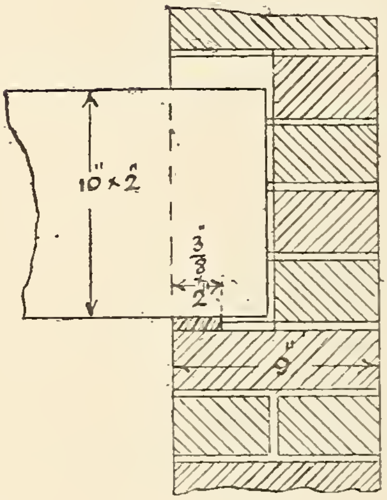


Fig. 232.

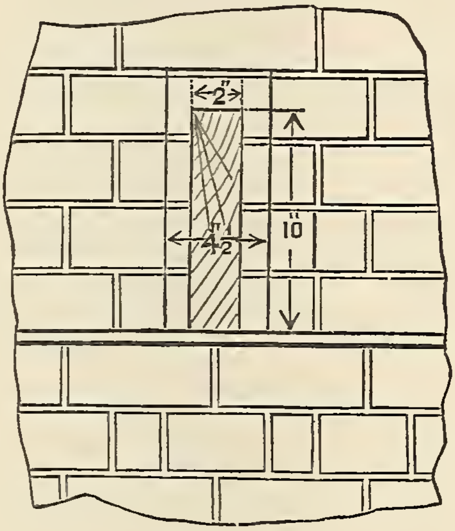


Fig. 233.

They are often notched but this is not good, as if there be a shake or defect in the timber below the notch it is liable to rupture by a load, which if the depth were not cut would be safely carried by the joist, as the effective depth of the joist is reduced by the depth of the notch. If however the plate be housed, as shown in figure 198, to take the bearing of the whole depth of the joist, any load tends to force together any shakes in the timber, and the full value of its depth is obtained.

The wall plate often has a fillet about 1″ by $\frac{3}{4}$″ nailed or worked on its upper surface, the joist being notched over; this is known as a cogged joint. The cog should always be nearer to the edge of the wall plate farthest from the end of the joist, so as to give the latter as great an area as possible to resist the detrusion or sliding of the projecting part.

Joints in Bridging Joists.—If it is necessary to make a joint in the length of a bridging joist, it should always be arranged to come over a binder. If there be no ceiling underneath, they should be bevelled halved together, care being taken that each joist has a bearing for its whole depth in the notching. If however the continuity of the centre line of the joists is of no importance, the joists should be laid side by side and spiked together. This is a stronger method, giving much greater bearing, and the joists are easily nailed together.

Trimming.—This is the method of arranging timbers to carry the ends of those bridging joists which are cut short to form openings or well holes and to clear flues.

These timbers which are cut short are termed trimmed joists, those which carry their ends and distribute the weight on the walls or other timbers are known as trimmers. The joists which carry the trimmers are called trimming joists, and these are generally parallel to the ordinary bridging joists.

Tredgold recommends that the trimming joists should be made $\frac{1}{8}$″ wider than the bridging joists for every trimmed joist carried, if the depth be the same, the trimmers to be calculated as binders. In practice however the trimmers are made of the same scantling as the trimming joists, the latter usually being one inch broader than the bridging joists.

Strutting.—Joists laid with boards on top, and lath and plaster underneath, are found to be insufficient to prevent bending and vibration under pressure. To remedy this, which is injurious to the walls and to the timber members, strutting is placed in straight continuous rows at intervals not more than 4 feet apart, which reduces to a great extent the defect.

The following are three methods of strutting:—

Herring-bone Strutting consists of pieces about 2 inches square, fixed as shown in figure 249. It is usual instead of boring for nails to make a saw cut at ends, and through this channel to drive the nail. By doing this any danger of splitting is avoided. This method has the recommendation that it acts where its leverage to prevent bending is greatest, viz., at the edges of joists, and is used largely in dwelling-houses.

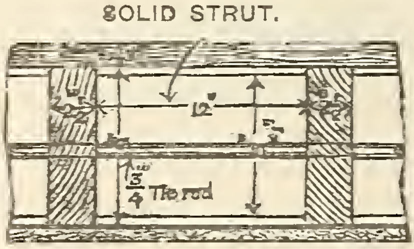


Fig. 234.

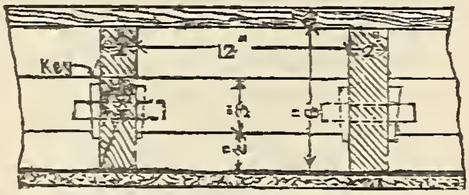


Fig. 235.

Solid Strutting.—One inch or $1\frac{1}{4}$ inch boards, nearly same depth as joists, are cut in tightly, and nailed between joists, as in figure 234. This method is greatly used for floors of factories and heavy buildings; and if cut, so that its entire shoulder butts against the joists, is undoubtedly the firmest method; but without care is exercised the shoulders are apt to bite on the centre only. Sometimes long bolts, either of round bar iron or gas pipe, are passed through all the joists, and the strutting crushed together with the joists and held tightly.

Key Strutting.—When the arrangement of fixing tenoned pieces mortised in joists and secured by keys is adopted, as shown in figure 235, it is known as key strutting. This construction is expensive, weakens the joists, and is not so effective as the previous methods, as the rows are not continuous, and therefore is rarely used in floors.

Joints of Flooring.—The following are the general methods of arranging the longitudinal joints of flooring (which may be drawn together by means of special cramps called dogs), and may be divided into two classes as follows:—

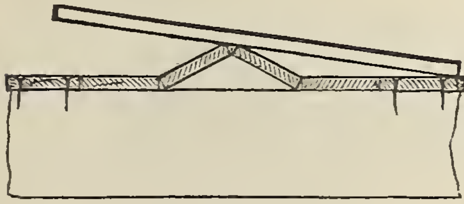


Fig. 236.

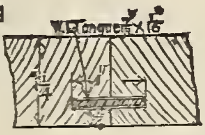


Fig. 237.

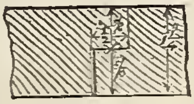


Fig. 238.

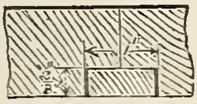


Fig. 239.

(*a*) Joints with visible fixing, as plain, ploughed and tongued, rebated, and rebated and filleted joints.

(*b*) Joints with secret fixing, as dowel, rebated, grooved and tongued, twice ditto, and splayed ditto joints, and these may be again sub-divided into joints, which do and do not admit of dust passing through when boards have shrunk.

Plain or Square Joint Laid Folding.—Square joints are forced together, if iron cramps are not obtainable, in the following manner:—About six battens are taken and laid into position; one outside is fixed and the others are pushed together, and the boundary marked. The loose outside batten is now fixed $\frac{3}{8}$ inch nearer to the board already fixed, and the others are placed, as shown in figure 236, with a plank across them, on which two or three men jump. This crushes the boards together, and closely fitting joints are obtained, and while kept in this position they are nailed to the joists.

Ploughed and Tongued.—A groove is made on each edge of board lower than the centre, so as to obtain as much wear as possible, and a wood or iron tongue is inserted which prevents edges curling up and any dust passing through, as shown in figure 237.

Rebated Joint.—For floors this joint has no special advantages to compensate for its extra expense, and is a construction not much used. It prevents dust passing through, as shown in figure 238.

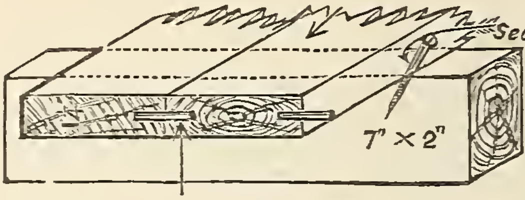


Fig. 240.

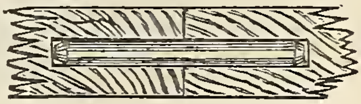


Fig. 241.

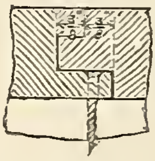


Fig. 242.

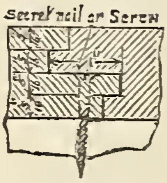


Fig. 243.

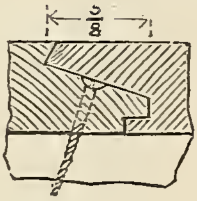


Fig. 244.

Rebated and Filleted.—The advantages of this method, as shown in figure 239, is that the greater part of the depth can be worn before the fillet is exposed, and is used in barracks and similar places where floors undergo heavy wear.

Secret Joints.—Important or polished floors are often required to be secured in such a manner as not to show their fixing, nor unsightly nail holes, as would occur in ordinarily fixed flooring; and should be free to shrink or swell without splitting, which is accomplished by fixing on one edge only. Figures 240 and 241 show a cheap and effective method, the boards being secured by dowel pins, and screwed to joists through one edge only; but to prevent dust passing through, ploughed and tongued joints should be used in combination.

Figures 242 and 243 show the methods by rebate, groove and tongue, secured by screws on one edge only. These can be easily fixed or taken up when required, and also prevent any dust passing through. The expense of these joints is the great objection to their general use. The method shown in figure 244 possesses the advantages of the two preceding and at a much less cost.

Heading Joints.—The joints between the ends of floor-boards are called heading joints, and may be square, splayed, or forked.

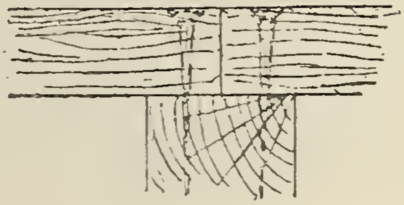


Fig. 245.

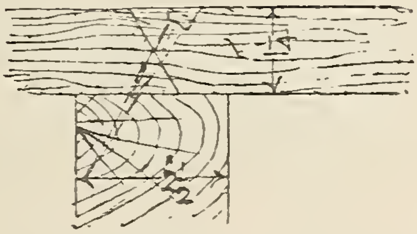


Fig. 246.

Square Heading Joints.—These are usually secured by two nails on each side of joint, as in figure 245.

Splayed Heading.—When the ends of boards are bevelled, only one board need be nailed, as in figure 246, and the splayed heading will effectually secure the end of adjoining board. This is the method usually adopted.

Forked Headings.—These headings are made with a series of triangular forks, which fit into each other, inclined to the length from 30° to 60°, as in figure 247. It is very expensive to make, and is only used in very good work.

Secret Headings.—These may be formed in a similar manner to the joints shown in cross section, figures 240 to 244.

Straight Joints.—This is the name given where the heading joints of adjoining boards are arranged on the same joist; such work looks unworkmanlike, as the plan of all heading joints should present a bonding appearance.

Broken Joints.—In old-fashioned floors, before the extensive use of machinery for joiners' work, boards of different widths were used, and it often happened that boards were laid as shown in figure 248. The interrupted longitudinal joint is then said to be broken.

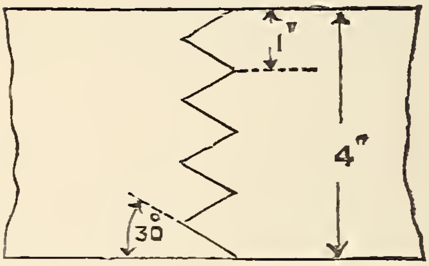


Fig. 247.

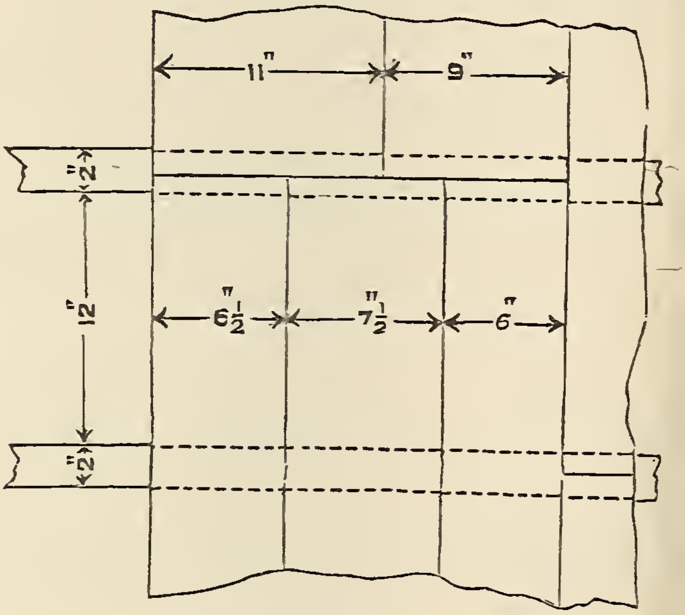


Fig. 248.

Prevention of Sound.—To prevent the passage of sound between rooms of lower and upper floors, the following methods may be adopted :—

First.—By reducing the number of through timbers the continuity of transmission is interrupted which lessens the sound, every fourth or fifth joist being made deeper than the others. To these the ceiling joists are secured, as shown in figure 249.

Secondly.—The most effective consists of a double system of joists, each system being entirely separate, not connected in any part. With this system no sound can be carried by conduction, and if all the members are bedded on felt, and the bridging joists strutted, as shown in figure, the passage of sound would be reduced to a minimum, as shown in figure 250.

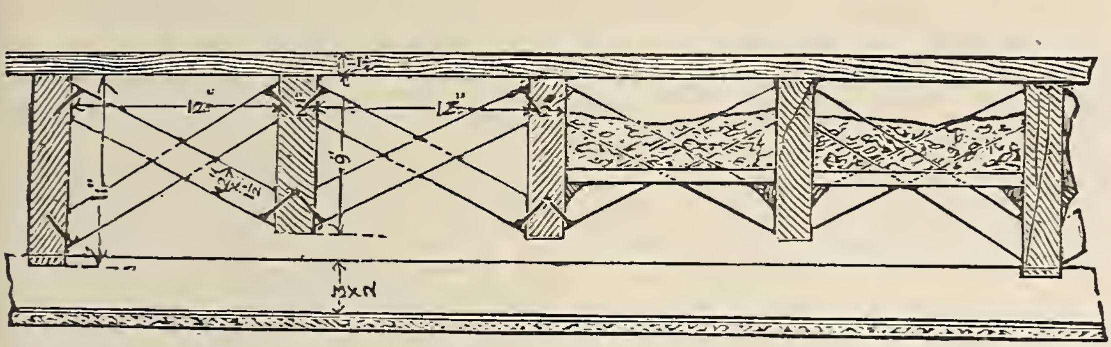


Fig. 249.

Thirdly.—Layers of list or felt are placed under every bearing of girders, binders, bridging joists, and floor boards to reduce vibration and sound.

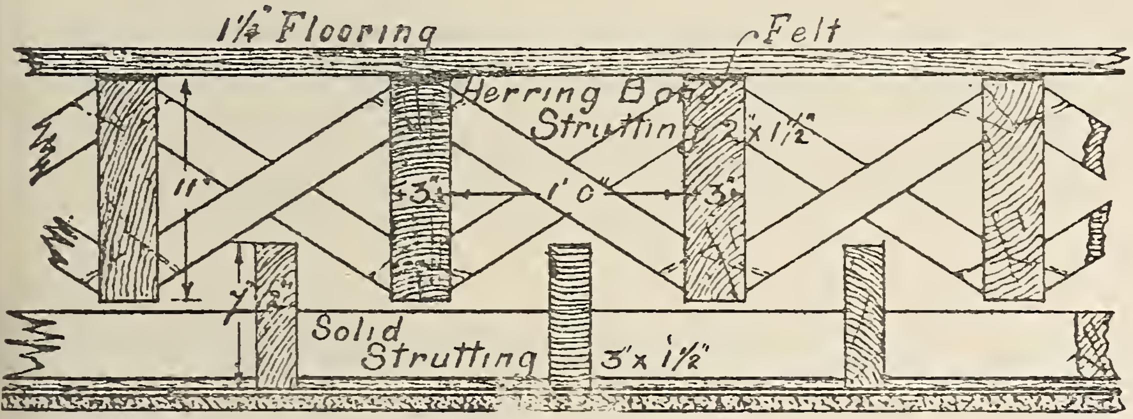


Fig. 250.

Fourthly.—Various methods of pugging are used to prevent the passage of sound, the object being to deaden the sound waves. They are never quite successful in preventing the passage of sound, and are objectionable as they induce dry rot in the timber, and the circulation of air is often impeded, if not entirely stopped, if the pugging is not near the top or bottom of the joists. The pugging employed may consist of coarse plaster, slabs of coke breeze, concrete, layers of slag wool, or slabs of fibrous plaster.

The fibrous plaster slabs are sometimes placed flush with the top of the joists, the entire floor space being covered with felt immediately beneath the boarding in order to deaden the sound. This is effective in reducing the sound, but does not protect the lower portion of the joists from fire. The better plan is to place the plaster slabs as close to the ceiling as possible, and have the tops of the joists only covered with felt. The flames would have a much smaller space to play upon, and the floor could be strutted and ventilated in the usual way.

Ceiling Joists.—These are the small joists that carry the lath and plaster ceiling only, and are suspended to other timbers. The usual dimensions are 3 to 5 inches × 2 inches, as smaller pieces might be split by the nails. They are fixed about 12 inches apart, and may be secured to the upper timbers by simply spiking, chase mortising or notching over fillets planted on sides to receive them, as in figures 253 and 254.

If $\frac{1}{2}$-inch is multiplied by the number of feet spanned by ceiling joists 2 inches thick, it will give the necessary depth.

Lathing.—Laths are fixed slightly apart to the under side of joists, the opening and space in rear allowing the plaster to pass through and protrude, thus affording a key for the plaster; and, therefore, should never be fixed on wide joists, as the key would be interrupted. Laths should be fitted with a butted and not a lapped joint.

Brandering.—If the joists are made thicker than

2 inches, to obtain the necessary key for plastering, fillets 1 inch square may be fixed to their underside, to which laths may be nailed; this method is called brandering.

Double Floors.—These floors consist of bridging joists and binders, with or without ceiling joists, and are used where the supporting walls are perforated with openings. Columns, piers, or the uninterrupted parts of walls are arranged to support the binders. The binders stiffen the floors, and, for reasons explained in page 108, decrease the sound passing from room to room if ceiling joists be used.

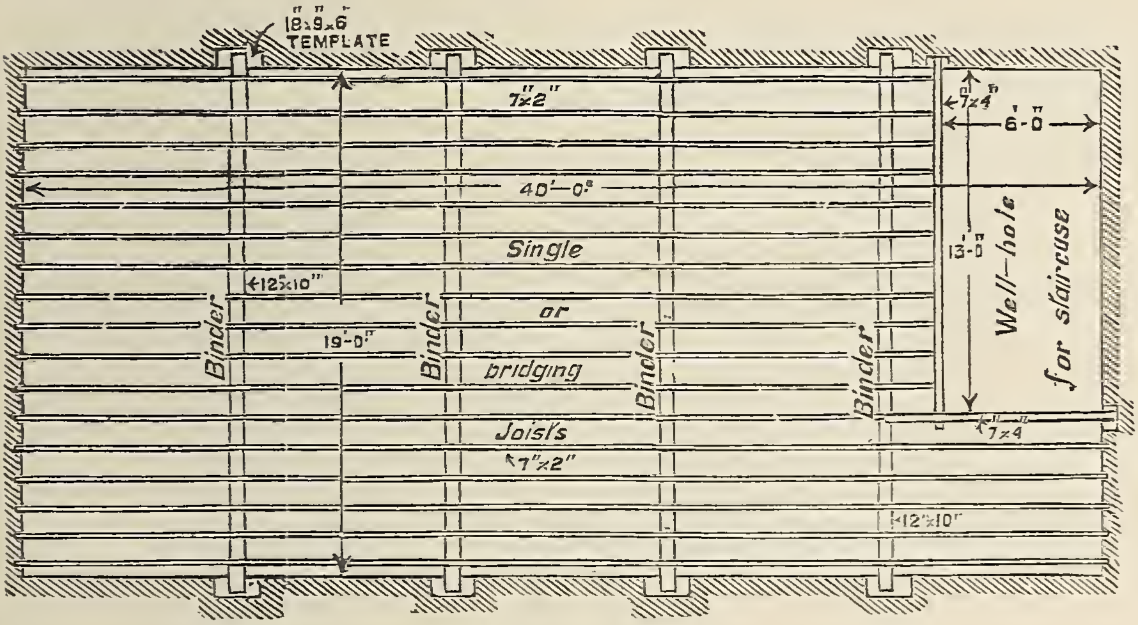


Fig. 251.

Figure 251 gives the plan of a double floor, the binders resting on stone templates built into walls. Ceiling joists, it any, are usually immediately under the bridging joist.

Scantling for binding joists of northern pine, distance apart from centre to centre, 6 feet, from Tredgold's "Carpentry":—

Clear span in feet.	Dimensions in inches.	Clear span in feet.	Dimensions in inches.
10	8 × 8	16	11 × 7¾
12	9 × 8	18	12 × 7½
14	10 × 8	20	12 × 9½

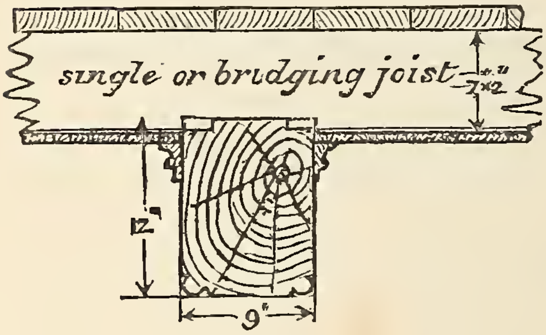


Fig. 252.

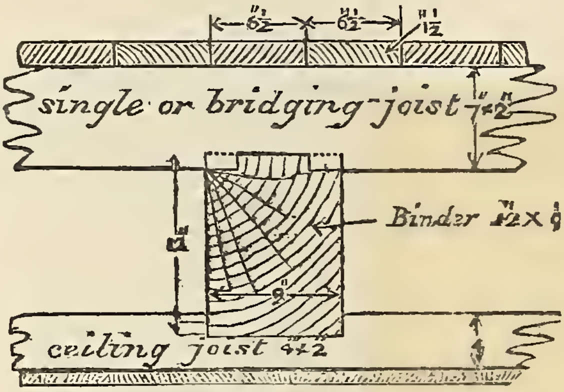


Fig. 253.

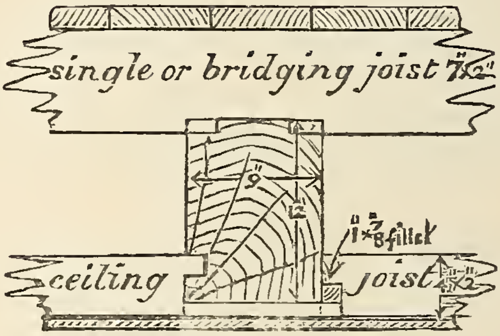


Fig. 254.

Double Floor Sections.—Figures 252 to 254 show ordinary methods of arranging binders to carry floor and ceiling joists. Where the extra height obtained is considered a greater advantage than efficiency of sound resistance, the lath and plaster ceiling may be attached to the bridging joists. The binder may be worked as illustrated in figure 252, which gives the ceiling a panelled appearance. If the projection of binder in lower room is an objection, the bridging joists are often housed a great portion of their depth and notched over the binders, but the extra cutting required will somewhat weaken the binders.

Wrought Iron and Steel Binders.—Rolled iron and steel joists are now extensively used as binders, the upper flange of which may support the floor joists, and the lower flange the ceiling joists, as in figure 255.

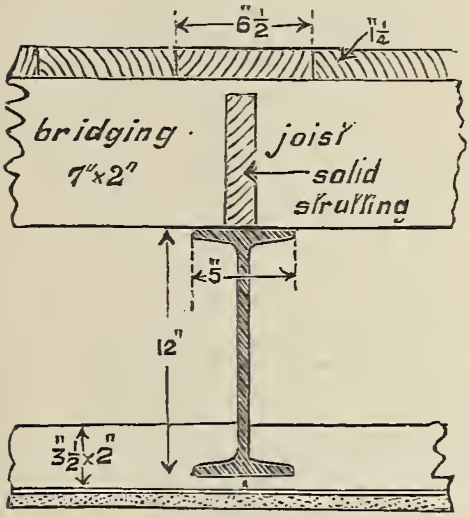


Fig. 255.

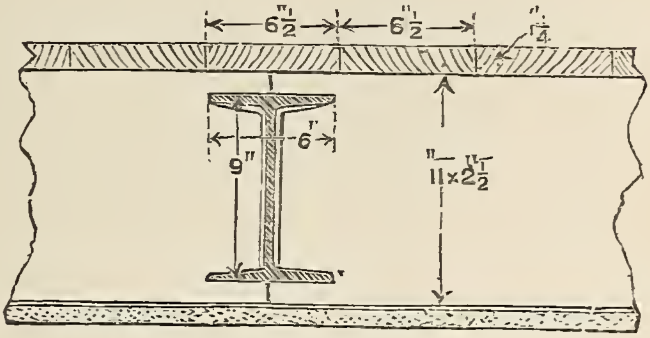
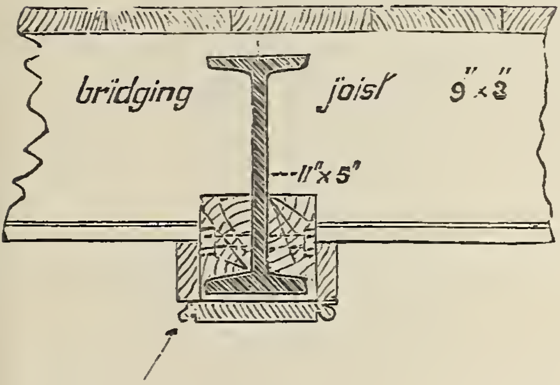
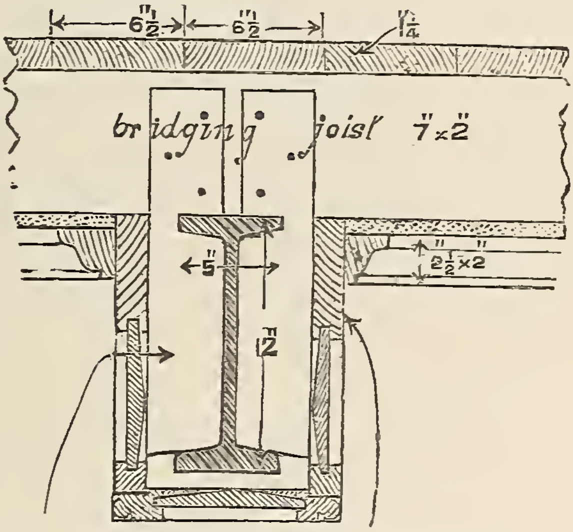


Fig. 256.



1in. beaded casing

Fig. 257.



1½in. aeal packing pieces *1¼in. framing.*

Fig. 258.

If the depth of the floor is required to be as shallow as possible, such joists for binders are useful, as the floor may be constructed without increasing the depth required by the bridging joists, as shown in figure 256.

Figures 257 and 258 show two methods of rolled iron or steel joists used as binders, to give the ceiling a panelled appearance.

Framed Floors are composed of bridging joists, binders, and girders, with or without ceiling joists, and are used in

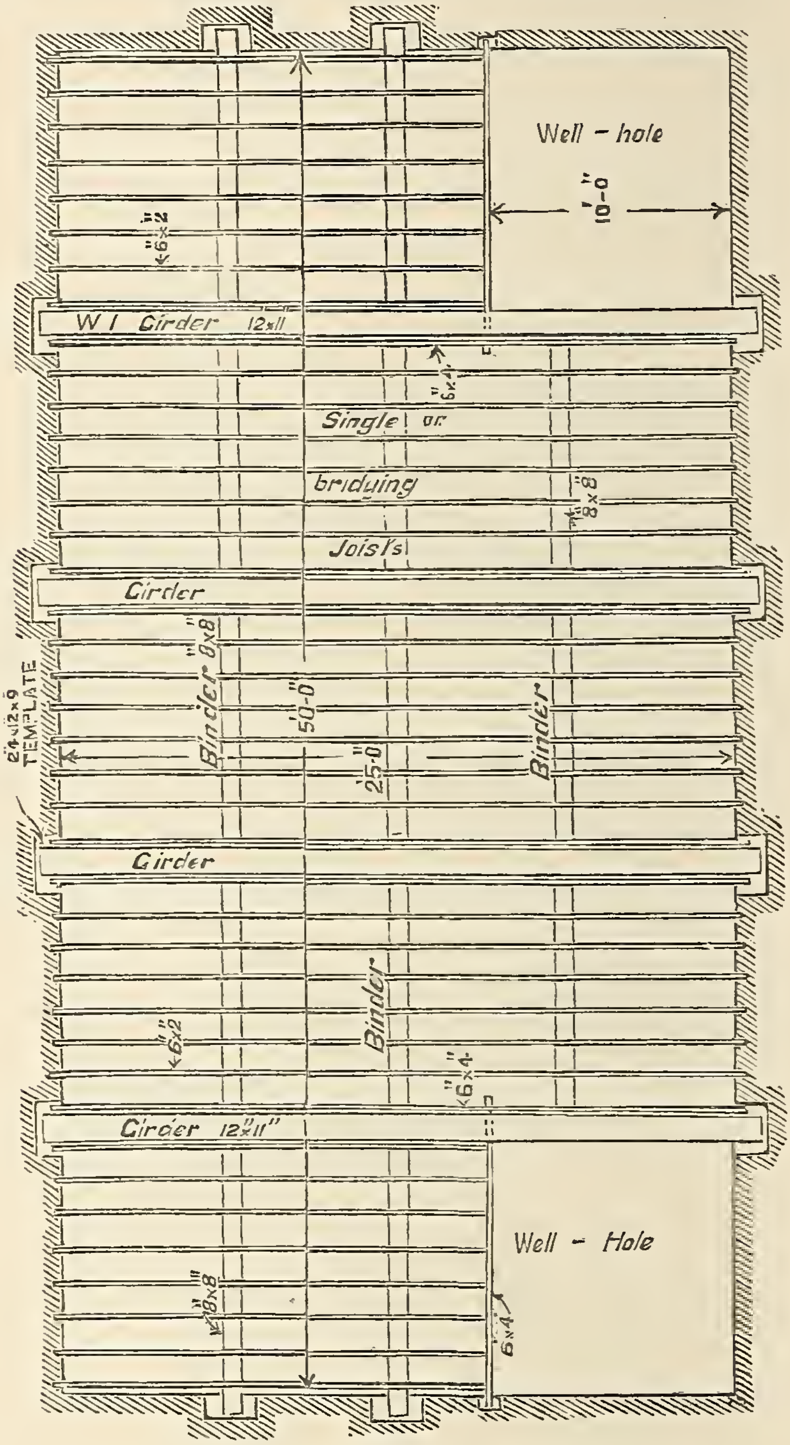


Fig. 259.

large factories, warehouses, and public buildings, where the span to be covered is great, or the number of supports are comparatively few, and have all the advantages of a double floor, but to a greater extent, as shown in figure 259.

Scantling for girders of northern pine, distance apart from centre to centre, 10 feet, from Tredgold's "Carpentry":—

Clear span in feet.	Dimensions in inches.	Clear span in feet.	Dimensions in inches.
10	10 × 7½	16	13 × 8¾
12	11 × 8	18	14 × 8¾
14	12 × 7¾	20	15 × 9

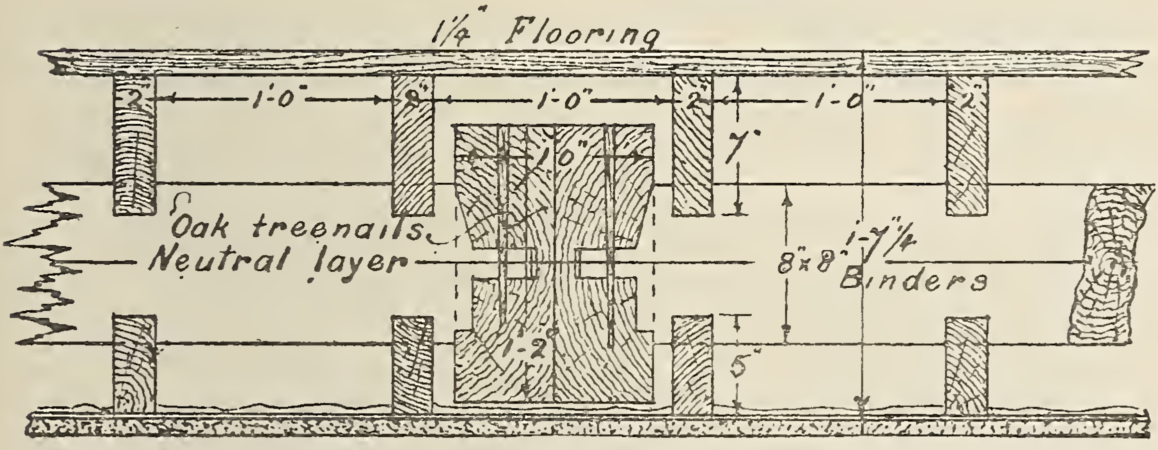


Fig. 260.

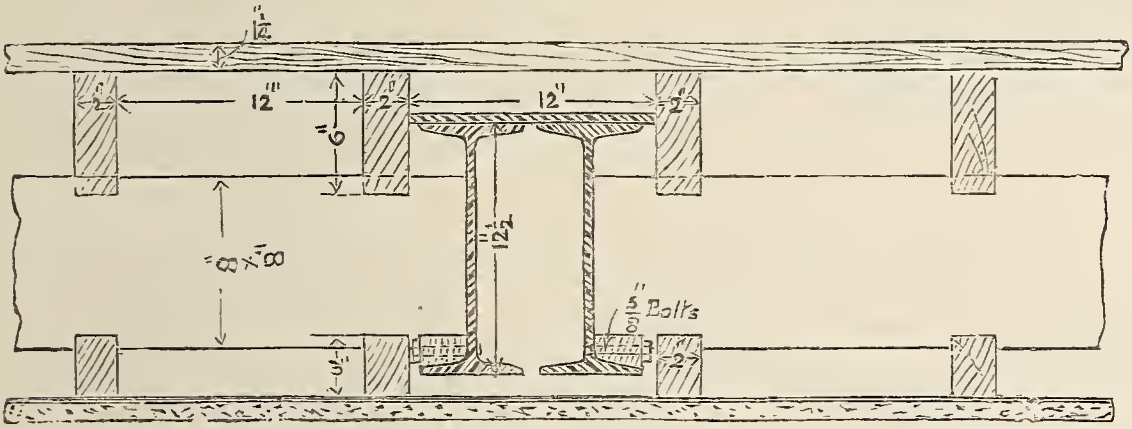


Fig. 261.

Figures 260 and 261 give methods of applying wood or rolled iron or steel joists as girders.

The binders in figure 260 are shown trenailed from the top side of the girder, but iron spikes driven through the vertical faces of the binders are often used instead to secure the binders to the wood girder.

Pockets in Walls.—All timbers penetrating walls should rest on stone templates, with a clear space of ½ inch at least, to allow of a free circulation of air around the ends of timbers, and, to prevent dry rot being induced, the ends of the timbers should in no case be allowed to touch the brickwork. Small cavities may be bridged at top with stone lintels, or the larger ones with rough relieving arch, as shown in figures 262 and 263.

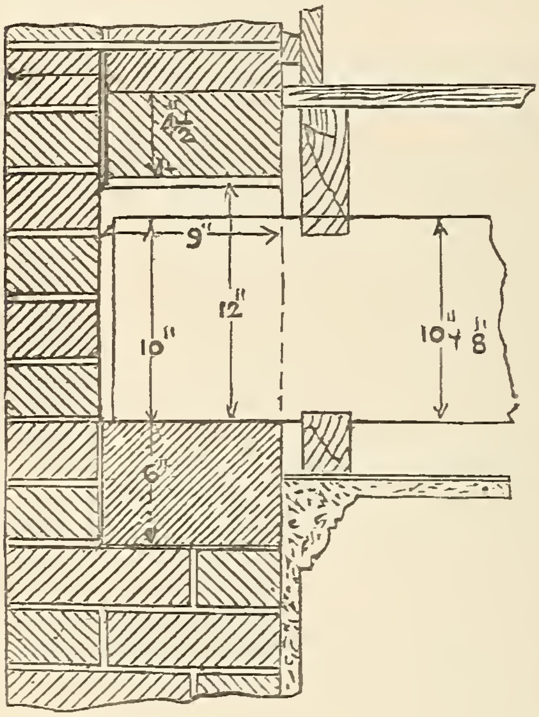


Fig. 262.

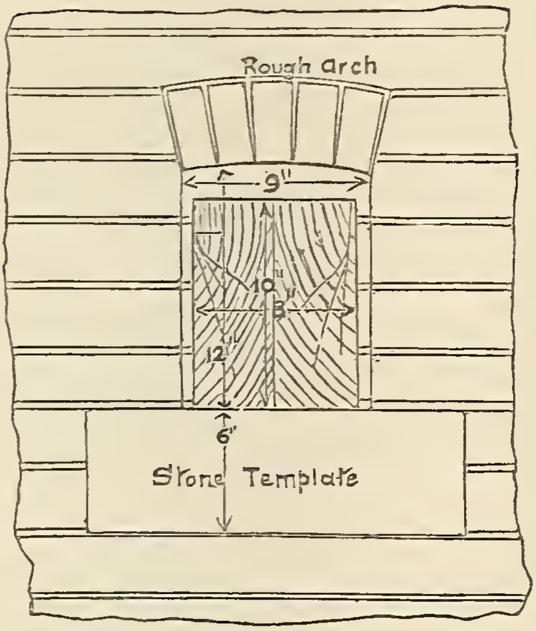


Fig. 263.

Ventilation of Floors.—All timbers of floors, especially those near the ground, should be well ventilated to prevent destruction by dry rot. The proper necessary ventilation may be obtained by the insertion of iron air bricks at intervals in the outer walls between ceiling and floor board levels, and by boring a number of horizontal holes through the joists at the centre of their depth, so that the air may circulate through all.

The ventilation is more complete when, instead of a few iron air bricks, a course of perforated bricks is inserted at two or more sides of the floor.

CHAPTER VII.

PARTITIONS.

Definition.—Partitions are screens used to divide flats into rooms, in addition to which they also often act as deep trusses to support floors.

Partitions may be built of brick, coke breeze, concrete or of wood, and also of various combinations of these materials.

Classification.—Timber partitions may be divided into three classes, viz. :—

(*a*) Common.
(*b*) Supported at ends and carrying own weight only.
(*c*) Supported at ends and carrying floors, roofs, etc.

Characteristics.—The advantages of timber partitions are first, lightness, an important consideration when the partition cannot have a solid bearing along its whole length, and can only be supported by a wall at either end. Secondly, rigidity, which is obtained by the triangulation of the framing; this also gives the walls a substantial support and aid in resisting external pressures. Thirdly, the facility of construction in any position, and the convenience with which loads may be transmitted and concentrated in any part or parts of the walls.

Timber partitions lack the fire-resisting properties of brick or concrete walls, and do not prevent the passage of sound to any great extent, and should not be erected in basements or floors next to the ground unless they are thoroughly protected from damp; brick or stone walls being preferable in this position.

Brick.—Brick is often used for partition walls which are built in the usual manner.

Coke Breeze.—Partitions are now largely built of coke-breeze concrete; 4 parts of breeze to 1 of Portland cement. Such material when used for partitions is usually supplemented by light iron tie rods, placed horizontally when fixed into the walls, and vertically when secured to light bar iron heads and sills. The concrete is poured into frames erected to receive it, in layers of about 1′ 6″ in height, until the whole is finished.

These partitions are light, fire-resisting and strong, the usual thickness of same being about 4½ inches.

Common Partitions.—Partitions designed to divide flats into rooms, where the floor is strong enough to support it, and consequently no need to truss the same, are called common partitions. They consist of a sill and a head with a number of uprights called studs tenoned to them, the whole fitting tightly between the floors below and above.

Care should be taken when placing the sill in position that it lies either at right angles to the floor joists below, or directly over one of the joists, if it be parallel to them, so that a solid and uniform support may be obtained along its entire length. Care must be taken that common partitions are not placed on the floor boards, between the joists, as in the event of the floor being taken up to be relaid, the partition would fail.

The studs, which consist of 4 × 2 quarters, placed 1′ 0″ to 1′ 3″ from centre to centre, are stump tenoned into the head and sill, and are stiffened in the direction of their length, by nogging pieces out of 4 × 2, cut tightly between the studs and nailed, or else out of strips 2″ × $\frac{3}{4}$″ let into the face of the studs and nailed, thus binding the whole together. The door studs, head and sill are formed of 4″ × 4″.

Bricknogged Partitions.—These are used for the prevention of fire and the passage of sound, and are a form of common partition; the spaces between the studs being filled in with brickwork 4½″ thick, the studs are made from 4 × 3 quarters, and are placed a distance of some multiple of a brick apart, usually either 2′ 3″ or 3′ 0″, and about every 2′ 0″ in height, a bonding strip out of 4″ × $\frac{3}{8}$″ should be placed horizontally between the studs and nailed to them. Bricknogged partitions must always have a thoroughly solid support along their entire length, otherwise they are liable to settle and crack the plaster and cornice.

If the partition be of small dimensions it might with advantage be made entirely of brick, but where the partition exceeds 10′ 0″ in height, or has to help to support a floor, wood studs and bonding strips should be introduced to avoid any injury from vibration or shocks.

Coke-breeze concrete is often used as a filling instead of brickwork, the studs having a number of nails driven in their sides, so that they project about 1½ inches to form a key for the concrete.

Partitions supporting their own weight.—These are employed when the floors are not strong enough to support the extra weight of a partition, and are therefore trussed so as to concentrate the weight of the partition on the

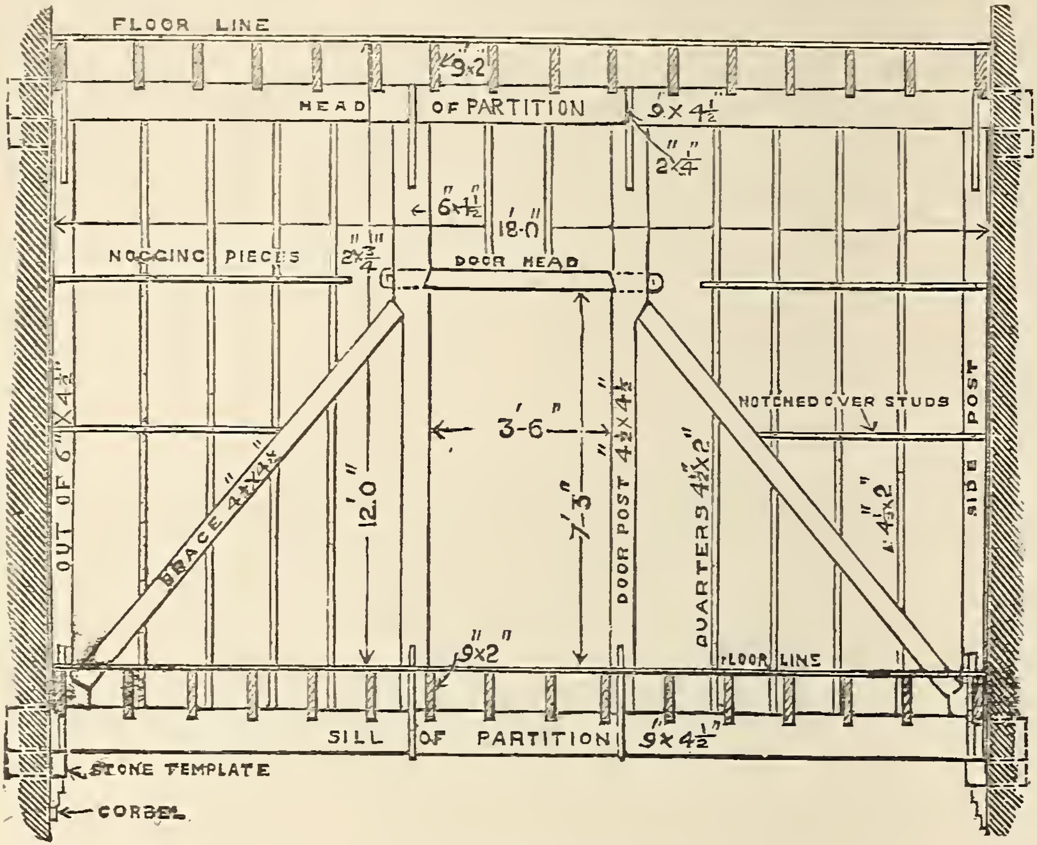


Fig. 264.

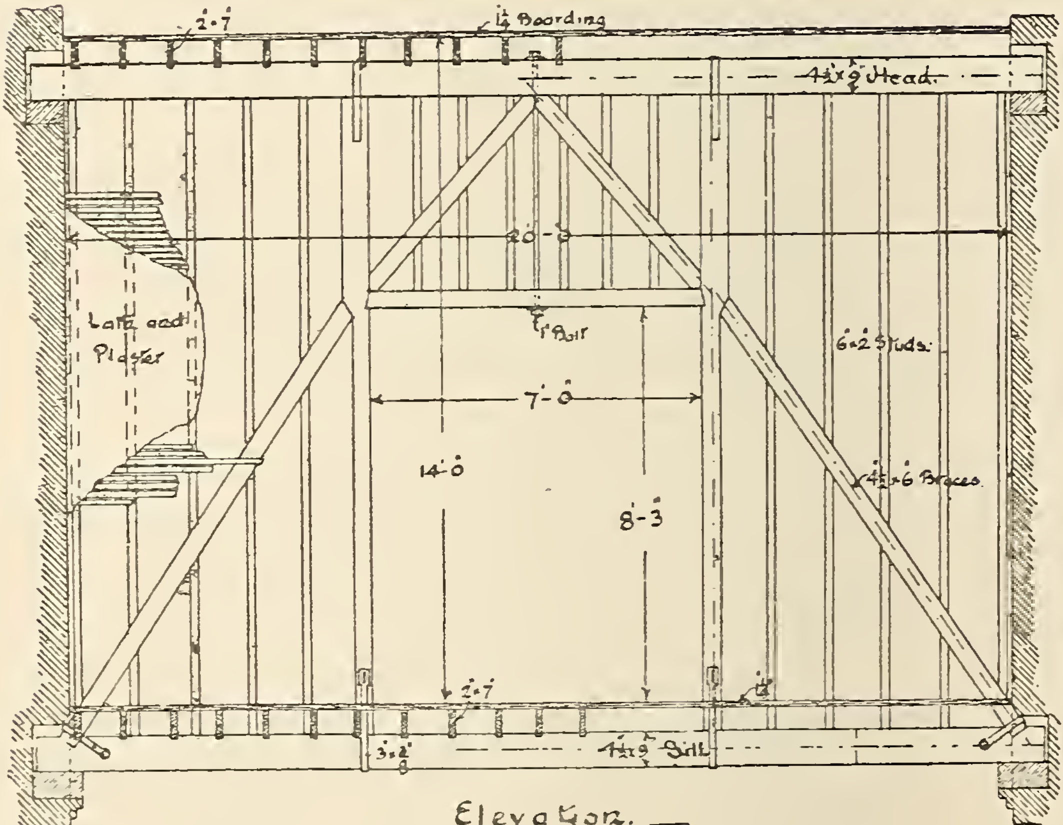


Fig. 265.

two supporting walls, as shown in figures 264, 265 and 266. It is better that the partitions should take their bearing on walls or supports at either end, and not rest on any intermediate support, such as a cross wall, at any point in its span, as the unequal settlement of the supports causes unsightly fractures in the plaster over the whole face of the partition.

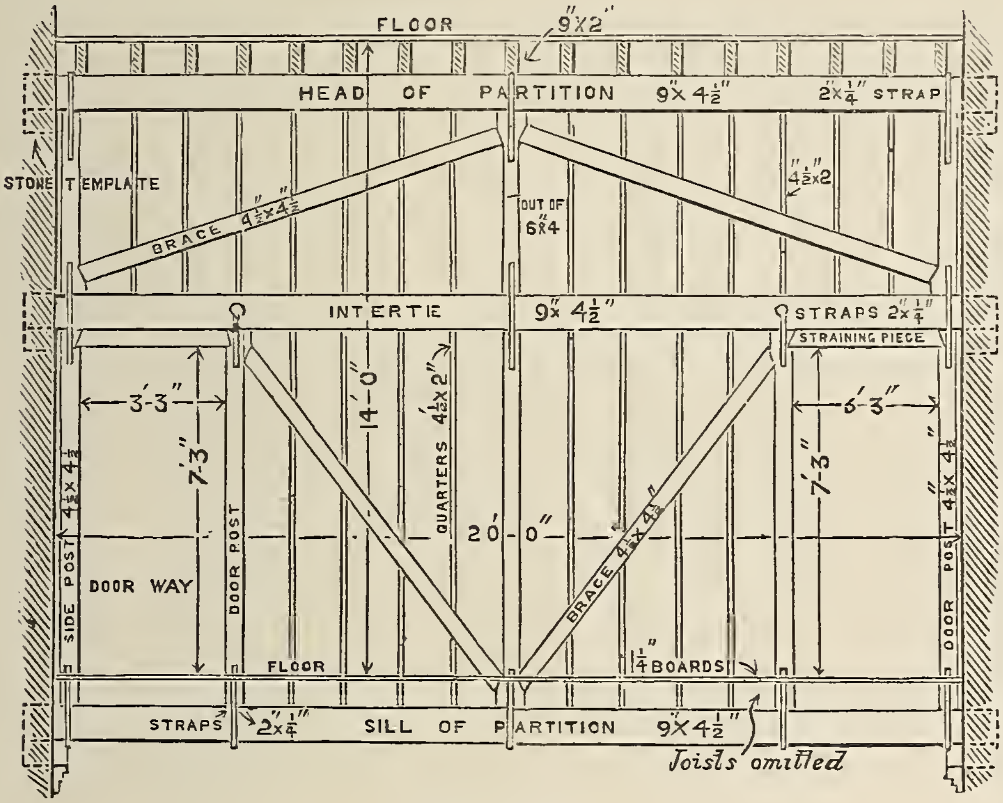


Fig. 266.

Trussing.—The object of trussing is to obtain a rigid unalterable frame, designed so as to throw all the weight carrying members into direct tension or compression, and to fail only when the members are stressed to their ultimate resistance. This is attained by triangulating the rectangular bays formed by the horizontal and vertical members by the addition of braces.

Distortion is prevented by arranging the loads to come over the apices of the triangles, when the stresses will be taken from all parts of the truss and transmitted to the supports.

All materials are inefficient to satisfy the theoretical requirements, owing to the expansion and contraction due to the variations in temperature. Timber is found to alter less in length than any other known building material, and is therefore well adapted for trussed frames, provided means are taken to prevent the shrinkage in width affecting its length.

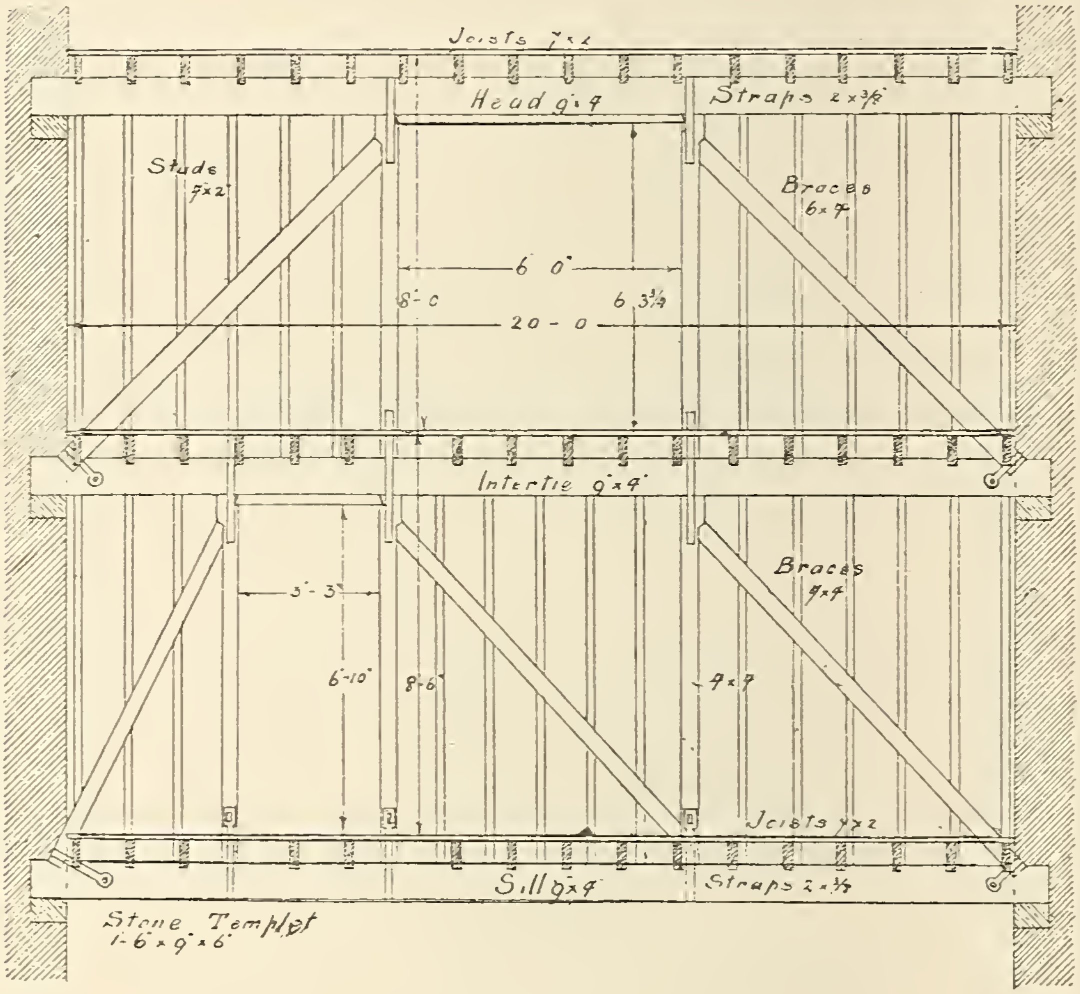


Fig. 267.

Care should be taken in designing the partition that the sill is supported at equal distances along its length as far as the door openings will allow; this is done by upright posts, tenoned into and connected to it by iron straps or bolts; the posts are supported at their upper ends by inclined braces, framed into them at that part, the feet of the braces being bridled into the sill at a short distance from the ends, the weight of the partition thrown on the sill is thus taken up the post and down the braces and transmitted directly on to the walls.

The tensional members in timber structures are always a source of weakness, owing to the difficulty of making the joints sufficiently strong, and such works are always supplemented by iron straps or bolts. Timber is often superseded by long iron bolts with heads and screwed nuts for the members in tension, as shown in figure 268.

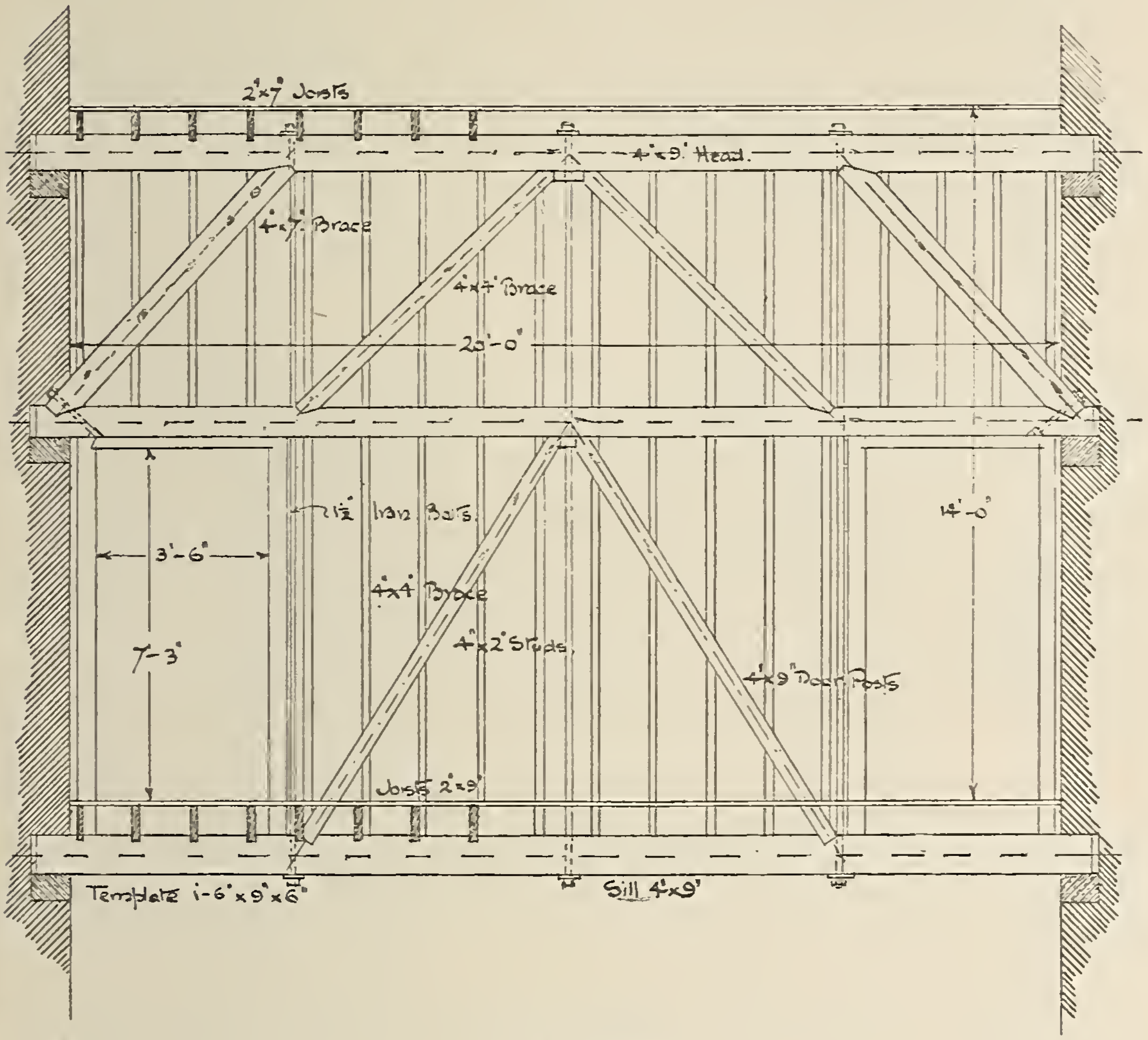


Fig. 268.

Partitions supporting Floors.—Figures 264 to 267 show partitions supporting floors, the principal difference between these and the preceding being that all the members have to be made proportionately stronger to carry the increased weight.

If the rooms be at all high another horizontal member is introduced, called an intertie, the duty of which is to distribute the pressure on the walls, and also to avoid the necessity of long braces.

The intertie is usually placed directly over the door heads, thus dividing the partition into two horizontal bays, which are trussed as before described.

In new buildings the plastering should be left until the walls have had time to settle, especially if they be of unequal heights and so allow the partition to adjust itself, otherwise the plaster will be cracked.

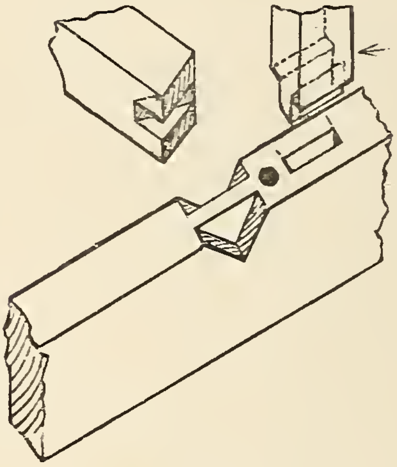


Fig. 269.

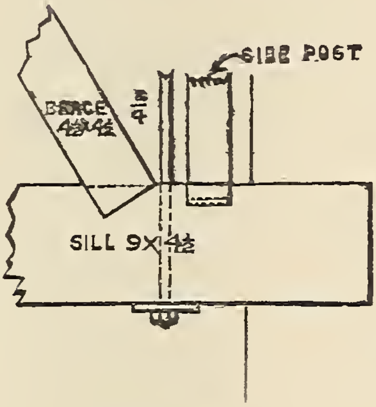


Fig. 270.

Studs.—The studs are stump tenoned into the sill head and intertie, as shown in figures 269 and 270, but where it intersects a brace it is simply cut to the bevil and nailed on, not tenoned into it, which would weaken the brace. The special duty of the studs is to form a fixing for the lathing, to interfere with the key of the plaster as little as possible; their thickness therefore should not exceed 2 inches. To resist the vibration and shocks caused by the slamming of the doors, the door studs should be stouter and generally 4″ by 4″; the angles are sometimes taken off these members to reduce the width on face with the object of preserving the plaster key, but a better method on all wide members is to counterlath, which consists in nailing laths at right angles to the covering lathing to all the main members of the partition of greater width than 2 inches.

Sills.—The sills in common partitions usually consist of 4″ by 4″ quarters, their special use being to receive the ends of the studs and to distribute the pressure evenly over the supports.

The sills in self-supporting partitions and those supporting floors vary in their depth, according to the weight to be carried. The sills receive the weight of the ordinary studs, which causes the former to be under a cross stress, and are supported at their two ends by walls and at intervals by being hung to the uprights by iron straps or bolts; they also receive at both extremities the thrust of the braces, causing them to be under a tensional stress.

Intertie.—The intertie acts in a manner similar to that of the sill, its chief duties being to receive the inclined thrust of the braces and divert the pressure into a vertical direction, and also to distribute the weight of the partition over the wall.

Heads.—The head serves as a fixing for the studs; as a support for the joists above, as shown in figures 264 to 267; and as a straining beam to resist the thrust of the braces at their upper ends. It should always be connected at its extremities to the lower horizontal members by bolts or tensional bars.

Braces.—The duty of the braces or inclined members is to give rigidity and to transmit the weight on to the walls, and care should be taken that these are always arranged so as to be in compression.

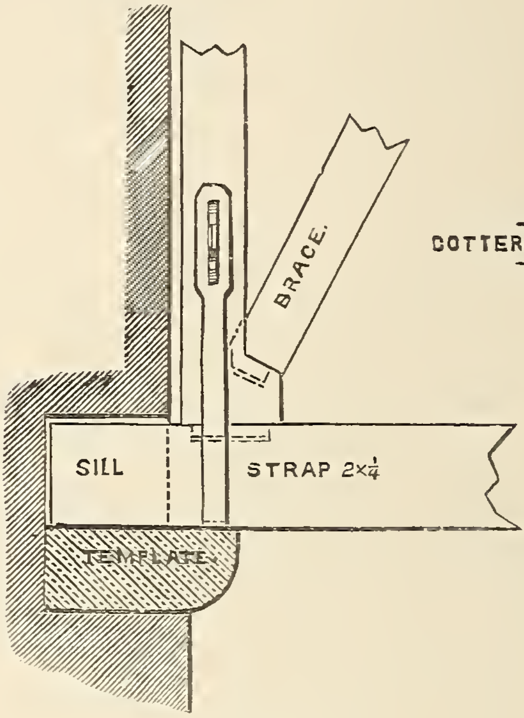


Fig. 271.

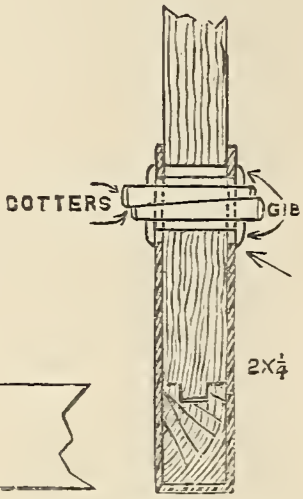


Fig. 272.

When wooden upright members are employed the ends of the braces are usually framed into the upright, with the exception of the lower ends when they occur at the extremities of the sill or intertie, at which part they should be framed into those members by a bridle or an abutment joint, as shown in figures 267 and 268, but where iron bolts

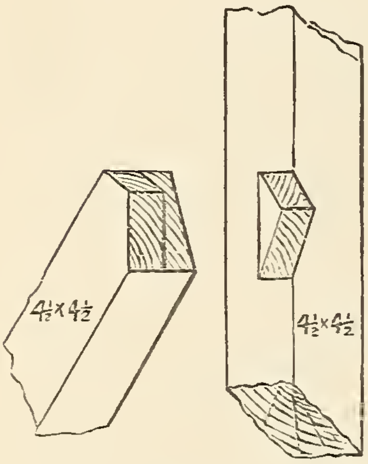


Fig. 273.

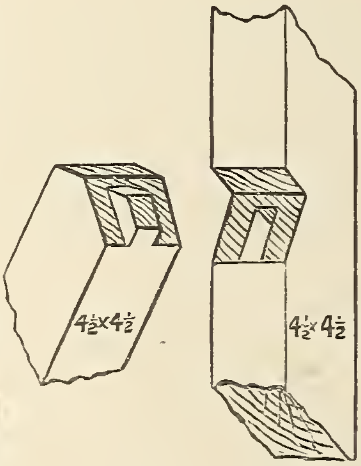


Fig. 274.

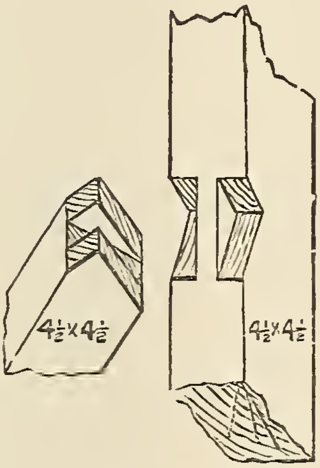


Fig. 275.

are used as tensional members, the joint at both head and sill should be a bridle, except where the extremities of two struts meet, and then they should be mitred and butted against each other, and the horizontal member, and stump tenoned into the latter.

Joint for Door Head.—Figure 276 shows a housed and tenoned joint for door head. The housing is to obtain bearing strength, and the tenon is keyed to draw shoulders up tightly.

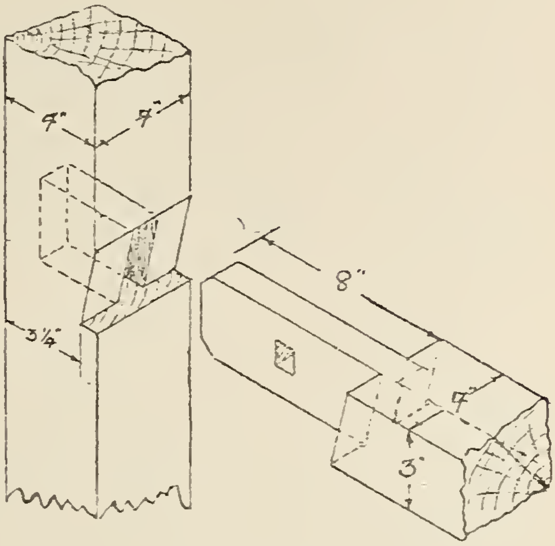


Fig. 276.

Fixing of Partitions.—The sill head and intertie should take their bearing on stone templates. If the partitions are arranged to act as cross walls they should be fixed, but if only to support themselves the ends of the timbers should rest in pockets so as to be thoroughly ventilated at all points.

The following are the scantlings of the timbers generally used :—

For common partitions, heads and sills	= 4″ × 3″
Door posts and head	= 4″ × 4″ and 4″ × 3
Studs	= 4″ × 2″

Double and Framed Partitions.—The scantlings of the principal members vary with the span, but are usually about the following :—

Heads	9″ × 4″
Sills	9″ × 4″
Intertie	7″ × 4″
Braces	4″ × 4″ to 7″ × 4″
Door Posts	4″ × 4″
Uprights	4″ × 4″
Studs	4″ × 2″

Weight of Partitions and Floors.—The weight of a square of partitioning may be taken at 1,480 to 2,000 lbs. per square of 100 feet.

The weight of a square of single joisted flooring without counter flooring, 1,260 to 2,000 lbs. per square.

The weight of a square of framed flooring with counter flooring, 2,000 to 4,000 lbs. per square.

Fixing for Plaster.—Wire netting fixed to the timber studs is a good method of forming the fixing for the plaster instead of wood laths.

Regulations.—The model bye-laws require that the open space inside any partition wall of a new building or between the posts in any wall of such building be stopped with brickwork, concrete, pugging, or other incombustible material at every floor and ceiling. With this exception the model bye-laws do not control the construction of partition or division walls which simply separate one room from another in the same house.

CHAPTER VIII.

WOOD ROOFS.

Definition.—The coverings or upper parts of buildings constructed over the enclosed space to keep rain and wind out and to preserve the interior from exposure to the weather, are called roofs. These should incidentally tie the walls and give strength and firmness to the structure.

They are built varying from almost horizontal surfaces to very steep pitches, the inclination being sometimes regulated by the climate, and should be designed to discharge any rain or snow that is likely to fall upon them. In countries favoured with mild weather, flat roofs would answer the purpose, whilst the colder climates and exposed positions would necessitate the use of steeply-pitched roofs. The latter require a greater amount of material than the flatter ones, and consequently are more expensive.

Pitch.—The steepness of a roof is usually indicated by the ratio of the rise to the span, which is known as the pitch.

Materials.—The following materials may be used as coverings for roofs. The following are the minimum inclinations, as given by Hurst :—

Covering.	Angle with Horizon.		Ratio of Rise to Span.
Tin	5°	43″	$\frac{1}{20}$
Lead	,,	,,	,,
Zinc	,,	,,	,,
Copper	7	36	$\frac{1}{15}$
Corrugated Iron	11	18	$\frac{1}{10}$
Asphalted Felt	18	26	$\frac{1}{6}$
Slates, Large	22	0	$\frac{1}{5}$
,, Ordinary	26	33	$\frac{1}{4}$
Thin Slabs of Stone	,,	,,	,,
Pantiles	33	40	$\frac{1}{3}$
Plain Tiles	45	0	$\frac{1}{2}$
Thatch	,,	,,	,,

In localities exposed to much wind and rain the pitch of slates should not be less than $\frac{1}{3}$ of the span. The angle of 45° is the best for slates and pantiles, and admits of the use of interior of the roof for the construction of garrets.

The timber used for members of roofs is usually northern pine, but for roofs of the class known as open timbered, pitch pine, oak, and chestnut.

Classification.—These may be classified in a similar manner to floors :—

(*a*) Single, consisting of common rafters, such as lean-to and couple roofs.

(*b*) Double, consisting of common rafters and purlins, such as roofs formed by common rafters, resting on purlins, supported by walls.

(*c*) Framed, consisting of common rafters, purlins, and trusses, such as mediæval, hammer-beam, and bracket roofs, arched rib trusses, couple-close, collar-beam, and all triangulated trusses.

Amongst the numerous forms of wooden roofs, the following are considered in the elementary stage :—

Flat, lean-to or shed, couple, couple close, collar beam, king-post and queen-post roof.

Flat Roofs are similar to floors, but having a waterproof top, the upper surface being constructed to drain water off, and may be made as a lead flat, or as an asphalted concrete roof, or in other ways, but as water or snow is not thrown off, any defect will be severely tested.

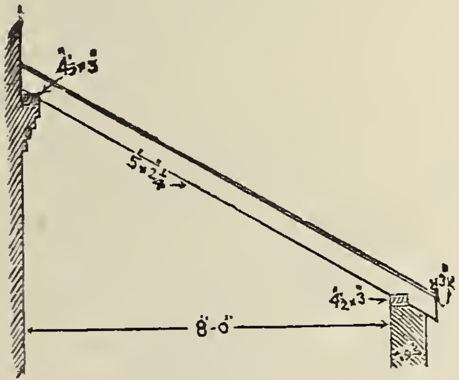


Fig. 277.

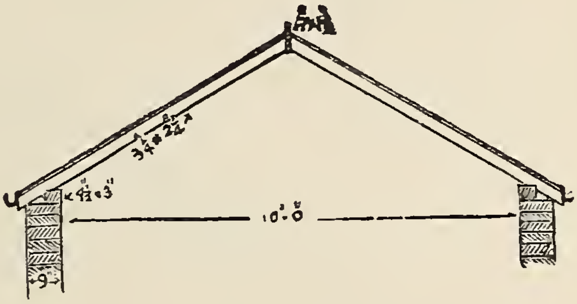


Fig. 278.

Lean-to or Shed Roofs are roofs formed with one slope only, used for outhouses against main buildings, as in figure 277, and for sheds.

Couple Roofs are roofs composed of rafters with their feet fixed to wall plates, and in modern work meeting with their heads butting against a ridge piece, and without any tie except that afforded by the wall plate, no ceiling joists being used, as in figure 278. Such construction should not be used in permanent structures of greater span than 12 feet, as the rafters have the tendency to thrust out the walls.

The scantlings given for couple close roofs are applicable for this method.

Couple Close Roofs.—For roofs about 12 feet in span, ties are used to prevent the walls from being thrust out by the rafters. The ties are usually formed by fixing the ends of the ceiling joists to the feet of rafters, as in figure 279.

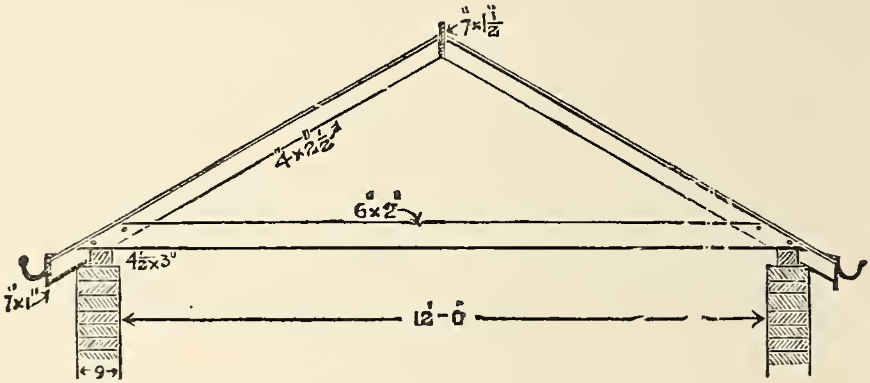


Fig. 279.

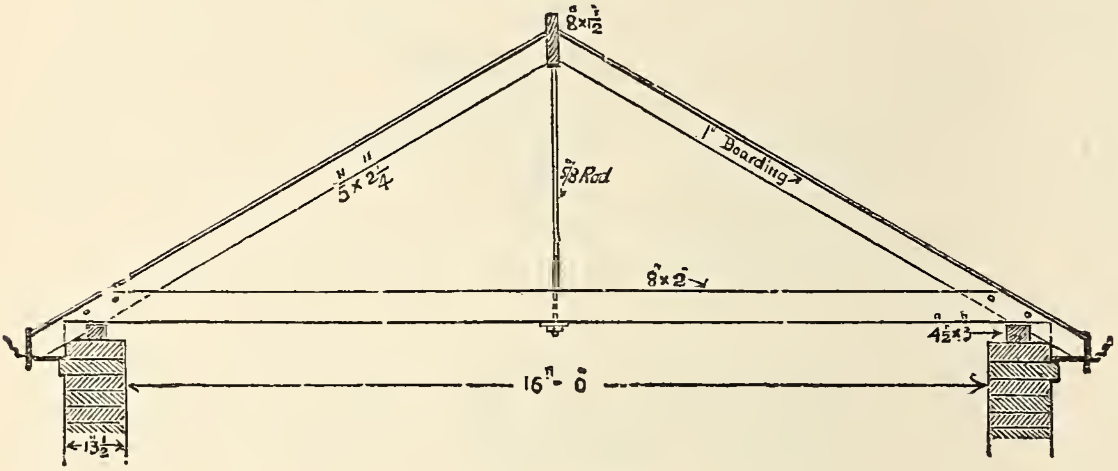


Fig. 280.

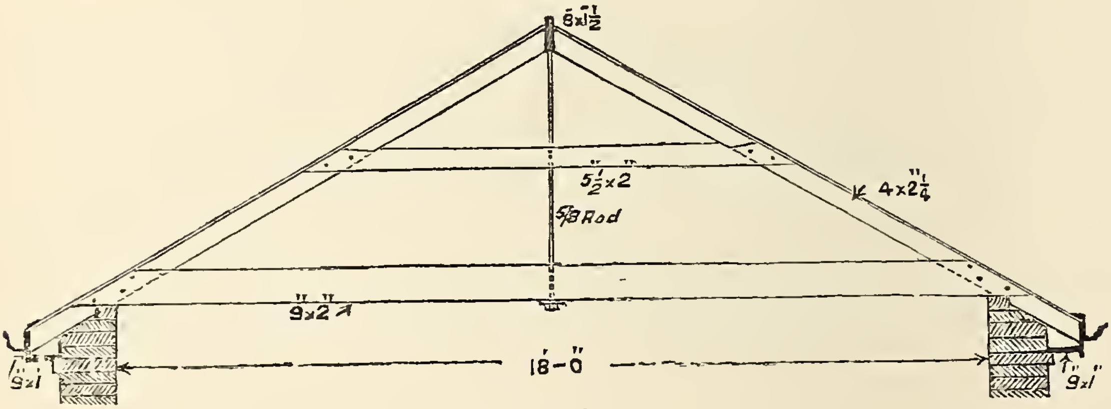


Fig. 281.

To prevent the bagging when carrying a ceiling, which would have the tendency to draw walls inwards, a king bolt is inserted, as in figure 280. The space in the roof is not altogether a waste, as it acts as a screen and a non-conductor of heat to the rooms immediately under same.

From 14 feet to 18 feet span it is wise to place a collar half way up the rafters to stiffen them, as in figure 281.

Scantlings for couple close roofs, of northern pine, rise ¼ span slated with Countess slates on boarding—as given by Wray:—

Span from centre to centre of Wall Plate.	Rafters.	Ridge Board.	Ceiling Joists.	REMARKS.
8 feet	2¾ × 2	7 × 1½	4 × 2	
10 ,,	3¼ × 2¼	7 × 1½	5 × 2	
12 ,,	4 × 2½	7 × 1½	6 × 2	
14 ,,	4½ × 2¼	7 × 1½	7 × 2	These spans should have a collar, but in that case the dimensions given for collar beam roofs may be used.
16 ,,	5 × 2¼	8 × 1½	8 × 2	
18 ,,	5½ × 2¼	8 × 1½	9 × 2	

Collar Beam Roofs.—Roofs of this description are constructed by fixing beams half way up to the rafters, to support the same, and carry ceilings which are attached to the underside, and the lower part of rafters, as shown in figure 282. If the wall plates are securely fixed in the walls, and the latter are of an ordinary thickness, this method answers without ties, and has the advantage of adding extra height to the room below; but directly the wall plates give, the collars become stretched owing to the feet of rafters spreading, and the result is that the walls have the tendency to fall outwards, and besides which the non-conductivity of heat is reduced, as compared with the preceding method.

The collars are sometimes suspended from the ridge board to prevent them sagging by carrying ceilings.

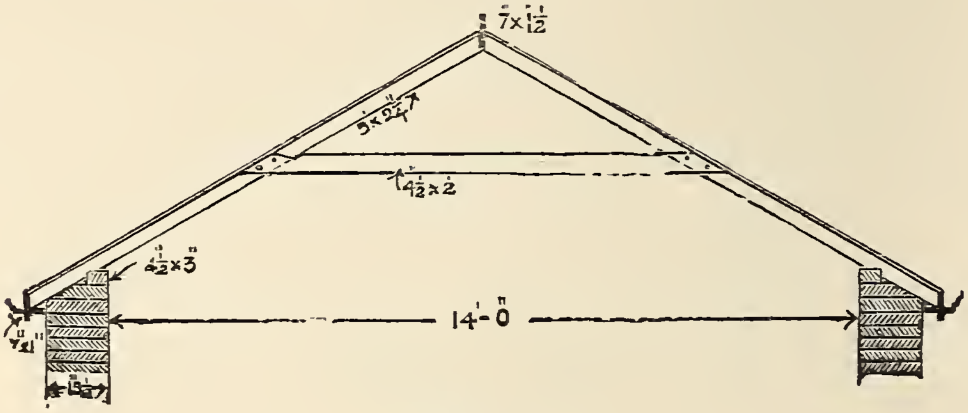


Fig. 282.

Scantlings for collar beam roofs, of northern pine, collar half way up without a tie, rise ¼ span slated with Countess slates on boarding—as given by Wray :—

Span from centre to centre of Wall Plate.	Rafter.	Ridge.	Collar.	REMARKS.
8 feet	3 × 2	7 × 1½	2 × 2	In these spans it is not necessary to use the collar, except to carry the ceiling.
10 ,,	3½ × 2	7 × 1½	2½ × 2	
12 ,,	4 × 2	7 × 1½	3½ × 2	
14 ,,	3 × 2¼	7 × 1½	4½ × 2	If there is no ceiling the collars may be reduced in depth, but they should be made thicker to prevent side buckling, as they will no longer be stiffened by the lathing.
16 ,,	3½ × 2¼	7 × 1½	5 × 2	
18 ,,	4 × 2¼	7 × 1½	5½ × 2	

Construction of Trusses.—The theory of trusses has already been stated in the chapter on Partitions.

Above 18 feet span the roofs already described will not answer unless the timbers are abnormally large, the expense and unsightliness of which prohibit their use. Above that length of span framed roofs should be used, with trusses usually not more than 6 feet to 10 feet apart. When it is desirable to have the trusses a greater distance than 10 feet apart, trussed purlins would be used to support the roof coverings, and distribute the weight on the trusses.

The trusses are timbers framed together, consisting of principal rafters, tie beam posts, and struts. These frames carry purlins and sometimes pole plates, which in their turn support the common rafters, and should be so constructed that every member is in direct tension or compression (with the exception of the tie beams carrying ceilings), the reason being that timber can resist very much greater loads when in direct tension or compression than when subject to transverse stress. This advantage is gained by designing triangulated frames, and arranging that the loads are supported at the angular points of the triangles. In setting out these frames it is wise to draw first the centre line of all the principal members, and to arrange the intersection of the centre lines of principal rafter and tie beam immediately over the centre of bearing, or within the middle third of the supporting wall.

The truss should be so arranged that the distances between the supporting points of the principals, or the unsupported lengths of common rafters, are not more than 8 feet. The king-post form would thus be applicable for a roof with a principal rafter 16 feet long, or for a span of 28 feet. The best position for purlins is directly over the joints of principal rafters and their struts, and for the feet of principal rafters directly over their supports, and the struts should be inclined to the horizontal as much as possible, and their feet on king-posts, kept as low down as is practicable, as shown in figure 284; and the ends of tie-beams should not be built into walls, so as to come in direct

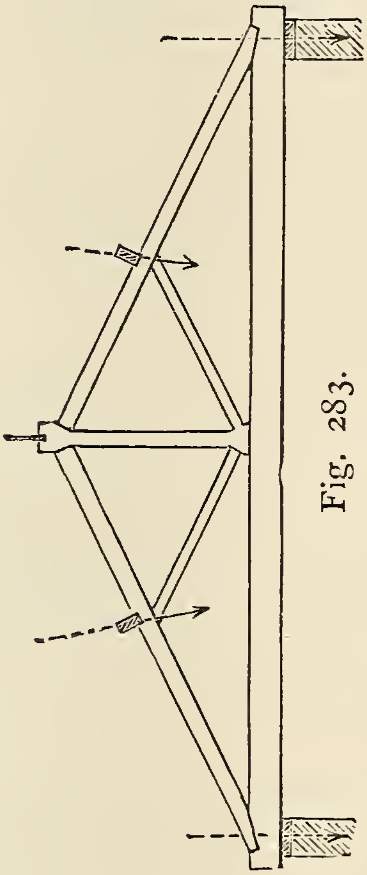


Fig. 283.

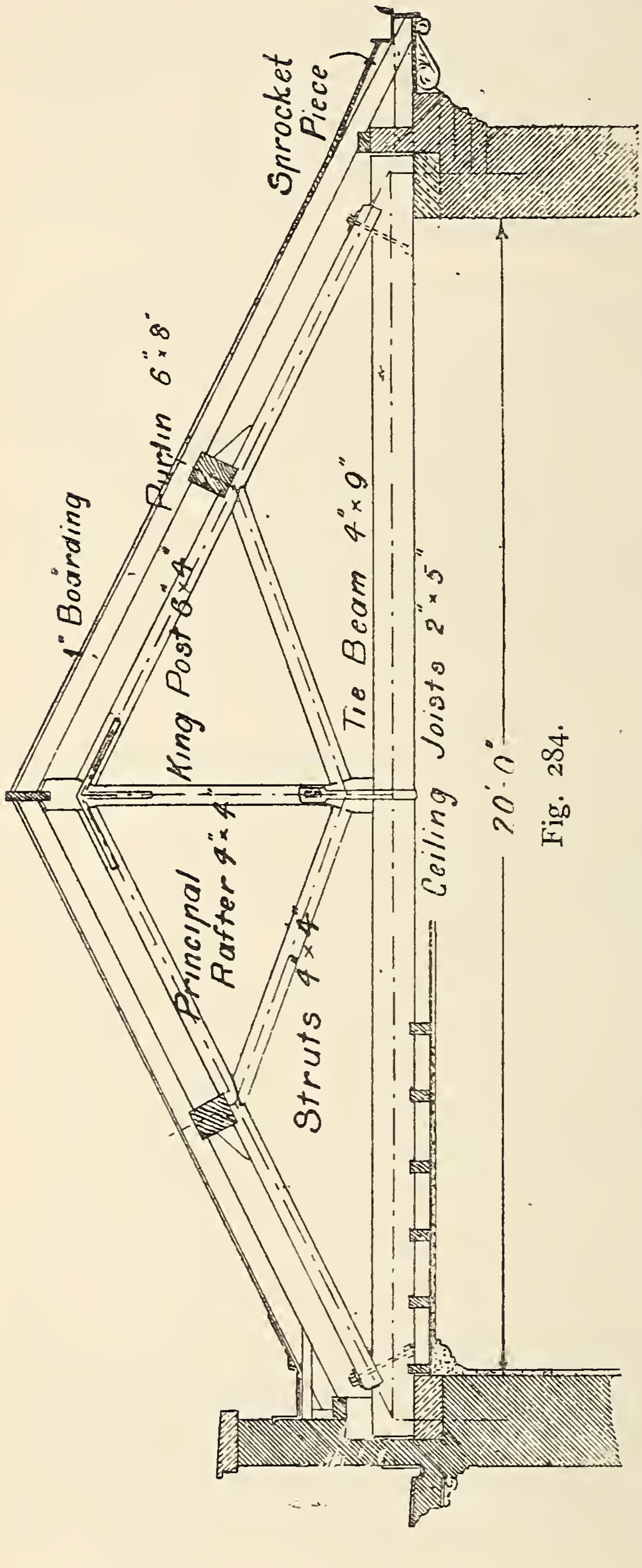


Fig. 284.

contact with the brickwork, which is more or less damp, according to the hygrometric state of the atmosphere; but should be so arranged where the tie beam supports the ceiling, that the timbers of roofs are just sufficiently ventilated to prevent the dry rot without destroying the valuable non-conductive properties of the comparatively still dry air chamber.

Figure 284 gives an illustration of a king-post roof-truss for 25 feet span, showing methods of arranging timbers to form taper-shaped parapet and eaves gutters. In London and adjoining districts all external walls, if adjoining gutter, to have parapet walls, at least one brick thick, 12 inches high, the height being measured from highest point of gutter, and party walls to have parapets 15 inches high above roof. The sole piece of taper-shaped gutters should never be less than 9 inches at lowest point, so as to be wide enough for a man to stand upon it.

Feet of Principal Rafters.—These should rest immediately over the walls, as in figures 284 and 290, the best position being the centre line of rafter meeting the centre line of tie beam perpendicularly over centre of support, as in figure 284.

Tie-beams.—It is advisable to let the ends of tie-beams rest on stone templates, over thickness of walls, or even project somewhat over where possible, as in eaves roofs, so that the load may be taken directly by walls; but, whichever method is adopted, care should be taken to ensure a sufficient circulation of air, to prevent timbers being attacked by the dry-rot. This may be accomplished by having dormers with louvre boards, as shown in Building Plates No. 15, or by purposely formed turrets with louvre boards fixed at highest parts of roofs, or, in roofs for stations, workshops, etc., where plenty of ventilation is no objection, by having open soffits to the eaves, and by various other methods which may suggest themselves.

Pole Plates are timbers supported only by the trusses, carrying the feet of common rafters, and are necessary where parallel gutters are to be formed, as in figure 472, or if all the load must be carried by the piers or portions of walls supporting tie-beams (to avoid any great load over openings that may occur in the wall).

Wall Plates.—Instead of using pole plates if taper-shaped or eaves gutters are to be constructed, the brickwork may be built up to carry wall plates, as in figure 284, which distributes a portion of the load of roof directly on the walls.

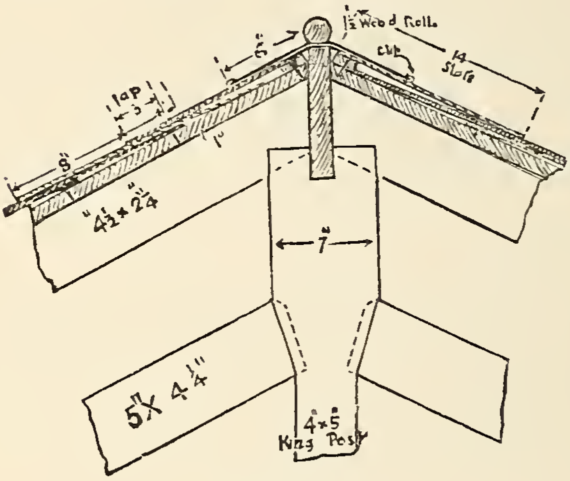


Fig. 285.

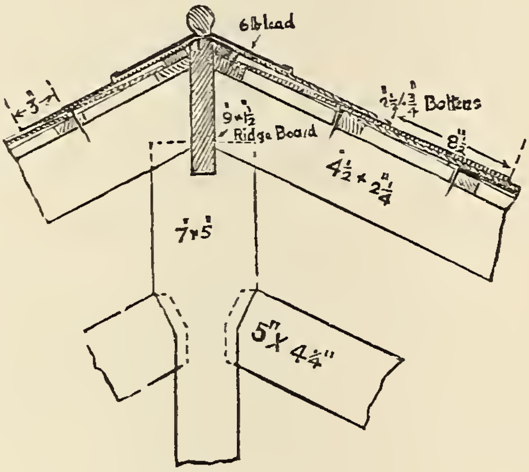


Fig. 286.

Gutter Bearers.—The gutter boards, usually 1 inch in thickness, may be supported by 2 inch by 2 inch, or 3 inch by 2 inch gutter bearers, which are halved and nailed to every rafter, as shown in figures 284 and 290.

Eaves Gutters.—One method of forming eaves gutters is shown in figure 284, and shows a wall plate directly supported by the wall.

Head of Principal Rafter.—Figure 285 shows a method of forming junction of principal rafter with king-post by a single shoulder. Where the difference of width of head and lower part of king-post is small, the joint may be made by cutting the upper portion of shoulder square with principal rafter, and the remaining part butting against king-post, as shown in figure 286, which may be secured by three-way straps, as shown in figure 284.

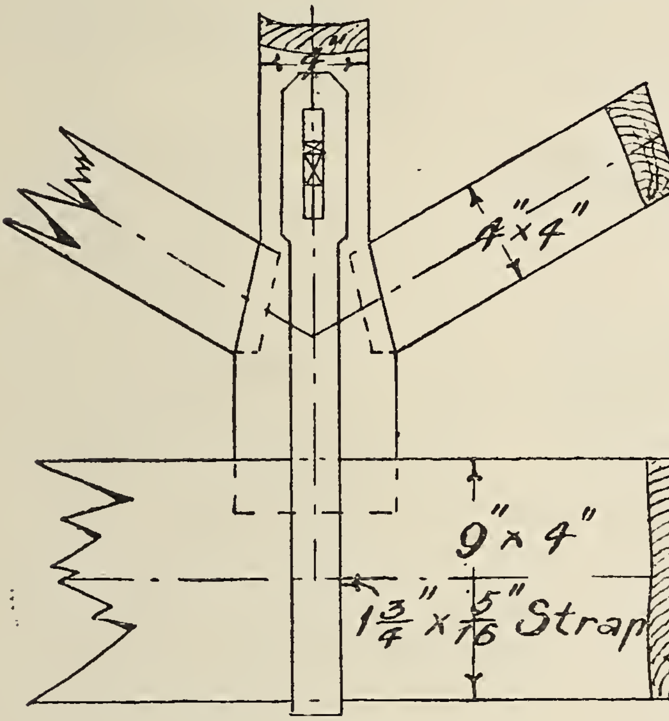


Fig. 287.

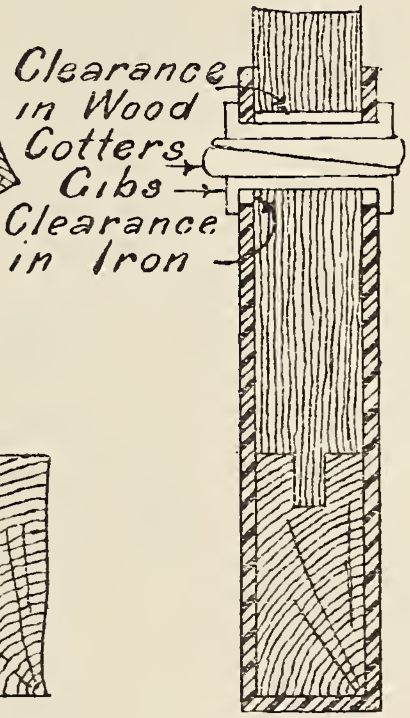


Fig. 288.

Ridge Boards are the highest timbers of roofs, and form the abutments for the heads of common rafters, which are usually spiked to them, but in good work are housed in. The ridge board may be held in position by slotting the head of king-post, as in figures 285 and 286.

Struts and King-post Joint may be made similar to head of principal rafter and king-post, under the same conditions; but the width of foot of king-post is usually sufficient to admit of the joint shown in figure 287, which being simple and easy to make, should always be used.

King-post and Tie-beam Joint.—These are sometimes held together by bolts only, the tie-beam being brought to the required camber by ropes suspended from the ridge (one inch in twenty feet generally being considered sufficient to prevent any unsightly settlement), the shoulders of king-post having been cut to the required length, or with straps secured by bolts; but the best arrangement is that of gibs and cotters, which allow the joint to be drawn up at any time an open shoulder is observable, by leaving clearances, as shown in figures 287 and 288.

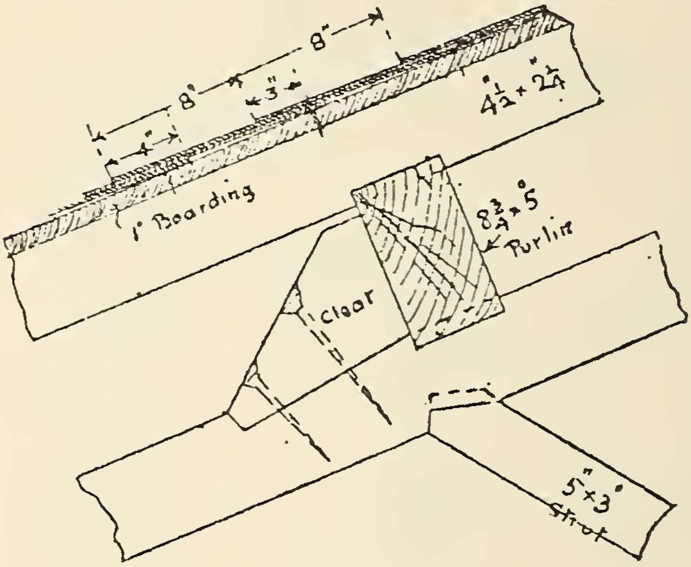


Fig. 289.

Purlins—Are the horizontal members of the roof, supported by the trusses, and which carry the common rafters between the pole or wall plates and the ridge pieces. They should not be more than eight feet from the next support of common rafters, and should be cogged to the principal rafters directly over the struts. In some forms of roofs, where common rafters are dispensed with, they carry the boarding to receive slating, as in figure 294.

Junction of Struts and Principal Rafters.—These may be arranged as in figure 289, and are sometimes held together by straps, and should be placed directly under the stress transmitted by the purlin above, as in figure 284; the latter distributing the load from roof above when acted on by the wind on that side.

Common Rafters are the sloping timbers to which roof coverings are attached. In framed roofs they are supported by pole or wall plates, purlins and ridge pieces, and should not have an unsupported length of more than eight

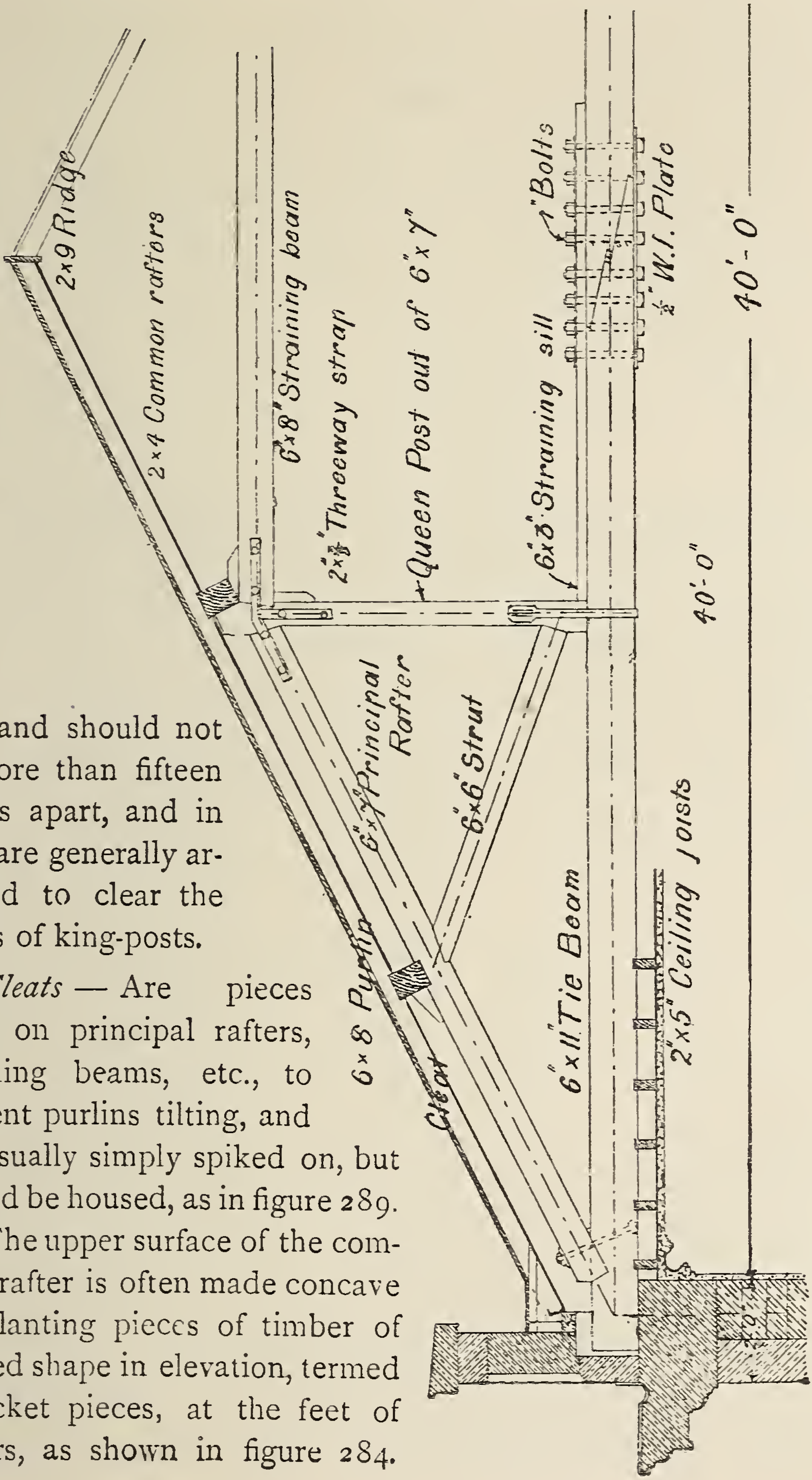


Fig. 290.

feet, and should not be more than fifteen inches apart, and in plan are generally arranged to clear the heads of king-posts.

Cleats — Are pieces fixed on principal rafters, straining beams, etc., to prevent purlins tilting, and are usually simply spiked on, but should be housed, as in figure 289.

The upper surface of the common rafter is often made concave by planting pieces of timber of curved shape in elevation, termed sprocket pieces, at the feet of rafters, as shown in figure 284.

This allows of slate or tiled coverings to fit with closer joints on their tail ends. Sometimes sprocket pieces are used to improve the appearance of roofs.

Queen-post Roof Truss.—Figure 290 shows an elevation of same, suitable for spans from thirty to forty-five feet, the parts being easily understood from what has been already stated about the king-post truss. The tie-beam, if of northern pine, is usually in two lengths, and scarfed. A straining sill is sometimes fixed between queen-posts to prevent the stress from struts shearing the tenon of queen-posts.

Scantlings for wood roofs, of northern pine—trusses 10 feet apart, ¼ pitch, slate covering (*Hurst's Handbook*) :—

Span in feet.	Tie-beam.	King-post.	Queen-post.	Principal Rafters.	Straining Beam.	Struts.	Purlins.	Common Rafters.
20	9½×4	4×3	—	4×4	—	3½×2	8×4¾	3½×2
22	9½×5	5×3	—	5×3½	—	3¾×2¼	8¼×5	3¾×2
24	10½×5	5×3½	—	5×4	—	4×2½	8½×5	4×2
26	11½×5	5×4	—	5×4¼	—	4¼×2½	8¾×5	4¼×2
28	11½×6	6×4	—	6×3½	—	4½×2¾	8¾×5¼	4½×2
30	12×6	6×4½	—	6×4	—	4¾×3	9×5½	4¾×2
32	10×4½	—	4½×4	4½×6¾	6¾×4½	3¾×2¼	8×4¾	4½×2
34	10×5	—	5×3½	5×6½	6¾×5	4×2½	8¼×5	3¾×2
36	10½×5	—	5×4	5×6¾	7×5	4¼×2½	8½×5	4×2
38	10×6	—	6×3¾	6×6	7¼×6	4½×2½	8½×5	4×2
40	11×6	—	6×4	6×6½	8×6	4½×2½	8½×5	4¼×2
42	11½×6	—	6×4½	6×6¾	8¼×6	4½×2¾	8¾×5¼	4½×2
44	12×6	—	6×5	6×7	8½×6	4½×3	9×5	4¾×2
46	12½×6	—	6×5½	6×7¼	9×6	4¾×3	9×5½	5×2

The members of king and queen-post roofs are calculated to resist the following strains :

Compression.—Principal rafters, straining beams, struts.

Tension.—King-posts, queen-posts, tie-beams without ceilings attached.

Transverse or Cross.—Purlins, common rafters.

Transverse and Tension.—Tie-beam with ceiling attached.

CHAPTER IX.

COMPOSITE ROOFS.

Definition.—Roof trusses built up of timber and of iron members are known as composite trusses.

Composite Trusses.—The ties of trusses in composite roofs are often constructed of wrought iron, because the latter has greater tensile strength than timber; moreover, the rectangular section in beams is wasteful, as the mortises or housings made at the joints in cutting the fibres considerably reduce the effective sections, consequently large pieces of timber have to be used to do the required work: this adds great weight to be carried by the supports, and interrupts the passage of light in open roofs. Wrought-iron ties would undoubtedly be oftener employed if it were not for the trouble and delay caused in getting small quantities executed, and the difficulty in fixing ceiling joists where such are required. Suspending the ceiling joists by iron straps to the ties is a somewhat unsatisfactory method sometimes adopted.

Objection.—Composite roofs of wood and iron are subject to this objection, that the timber principals neither expand nor contract appreciably with the changes of temperature, while the iron members do so considerably. This can easily be imagined to have the effect of lengthening the tie until it ceases to act, or until the feet of the principal rafters spread; or, again, the contraction of the iron tie rod may have the effect of bending wood principals or overstraining the tie rod.

Tie-beams and Principal Rafters.—In open roofs, iron ties may be advantageously used, but ceiling joists are more easily fixed to timber tie-beams. The principal rafters in composite roofs are always in timber, owing to the facility with which purlins may be fixed, and to high resistance of rectangular sections of timber to compression.

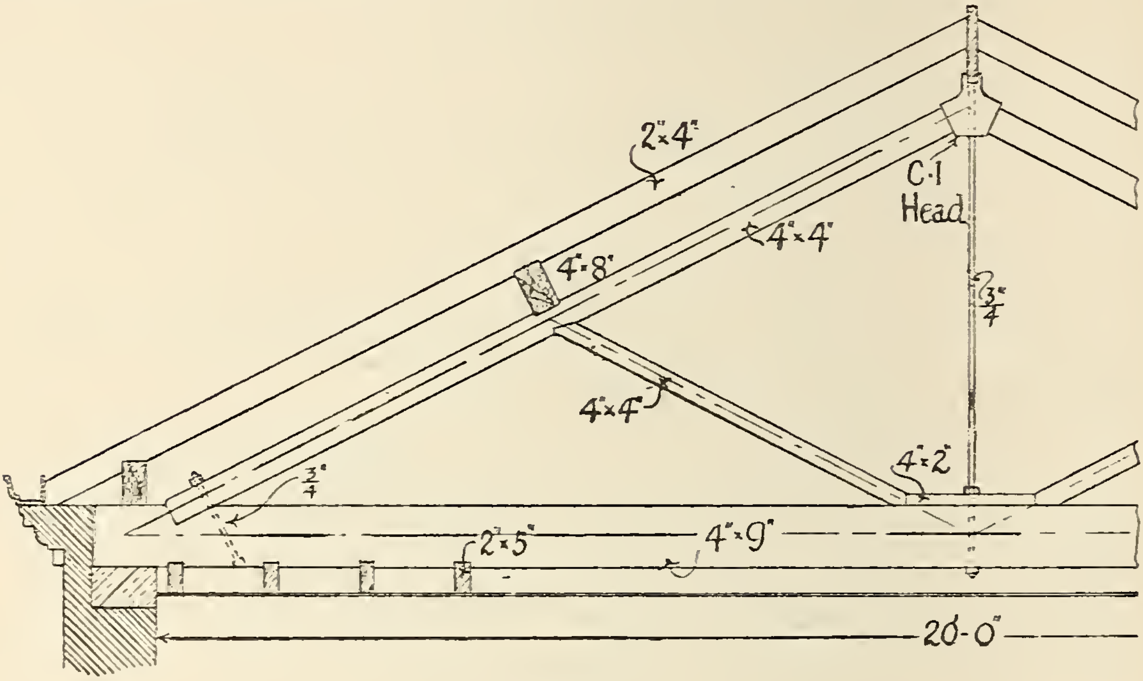


Fig. 291.

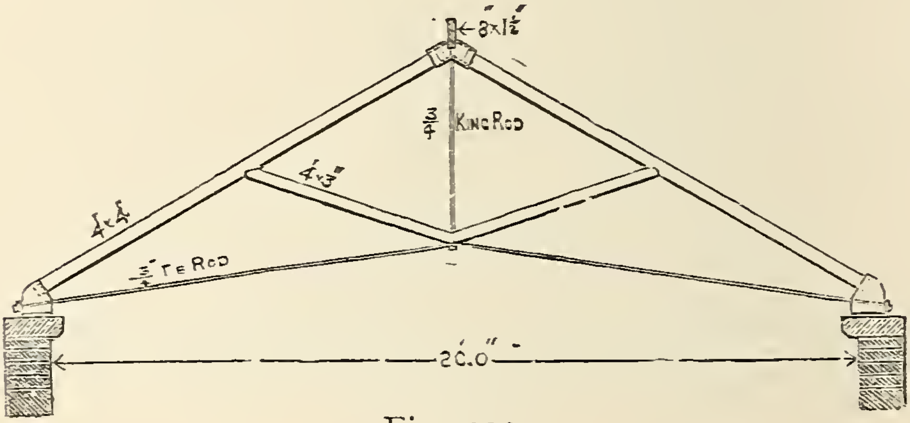


Fig. 292.

Typical Trusses.—The following are typical composite trusses :—For spans of from 20 to 30 feet.

Figure 291 shows a wrought-iron king bolt and cast-iron head, the joint at the foot of the struts being made by introducing a straining piece. Figure 292 illustrates a truss for a 20 feet span, the tensional members being of wrought iron, while the struts and principal rafters are of timber.

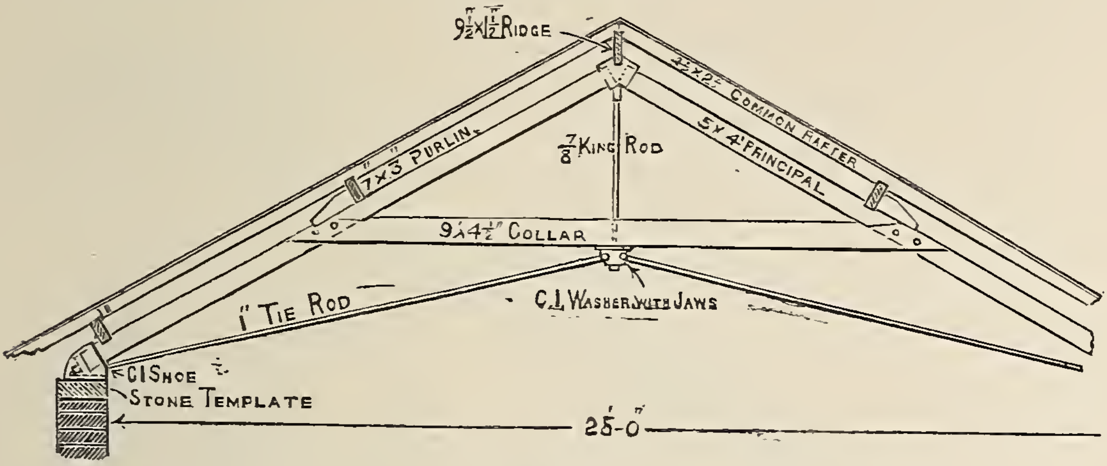


Fig. 293.

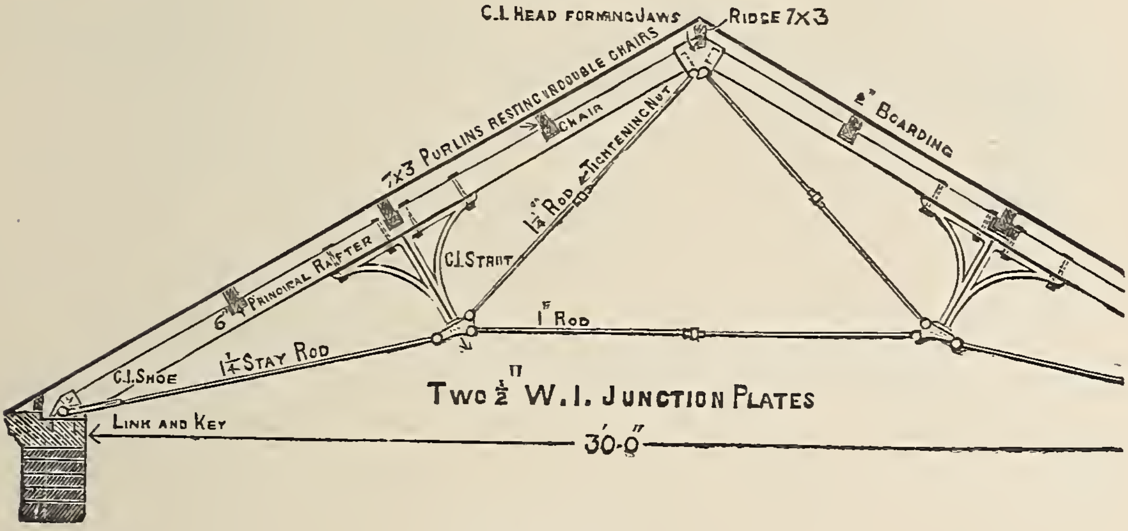


Fig. 294.

The German truss, as shown in figure 293, may be used, introducing a king bolt and tie rods, those being the members in tension, as illustrated in figure 293.

This form follows the lines of the timber collar beam truss, but with tie-rods to overcome the horizontal thrust instead of wood gusset pieces.

Figure 294 shows wrought-iron tension and tie rods with cast-iron struts, the principals alone being of timber.

For spans from 30 to 40 feet, the king bolt and queen bolt forms of truss may be used, those members being of wrought iron and constructed as illustrated in figure 295. The tie-beam being of timber and well tied up by the king and queen bolts, render these trusses suitable for supporting a ceiling.

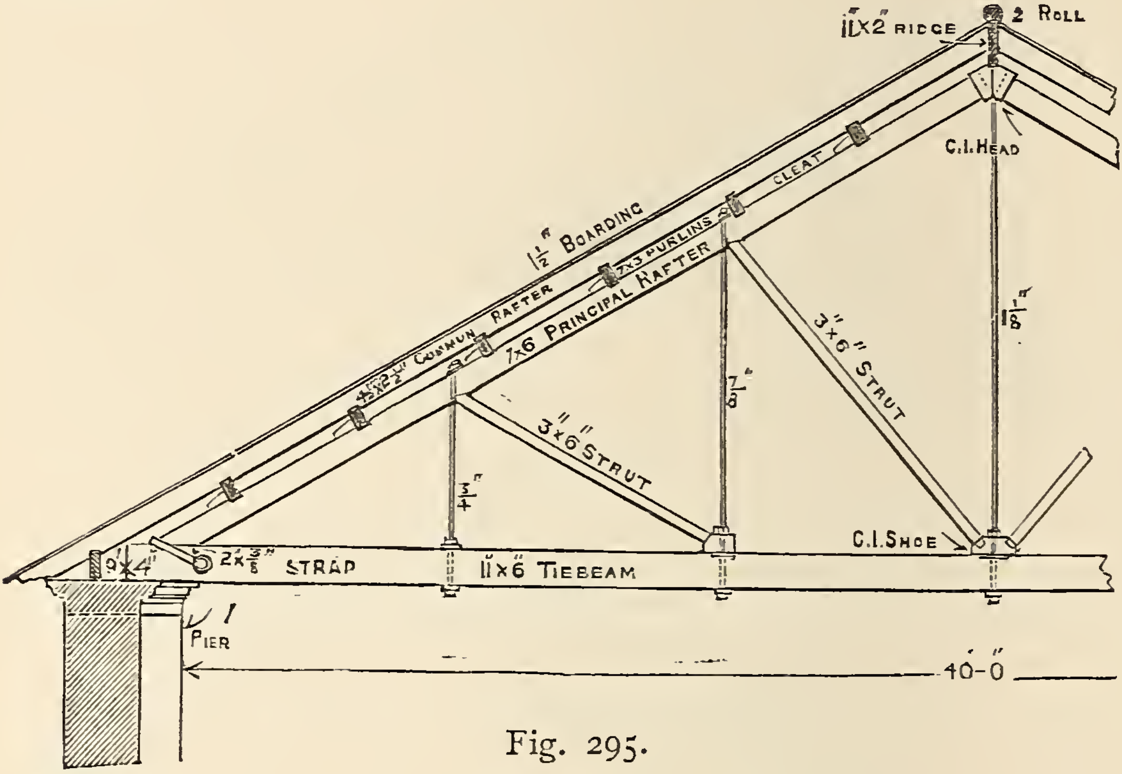


Fig. 295.

Feet of Principal Rafters.—Iron ties may be secured to wood principals by the aid of a cast-iron shoe, which receives foot of principal, and is drilled to receive tie as illustrated in figure 297.

Head of Principal Rafter.—Cast-iron heads are made to form the abutment for the upper ends of principal rafters, with a hole cast for the king bolt to pass through, as shown in figures 299 and 300.

Timber Strut, Principal and Queen Bolt.—The usual joint between the strut and principal is a single abutment with queen bolt passing through a hole bored through the principal, and fixed by a nut screwed on bevelled washer to back of principal, as shown in figure 295.

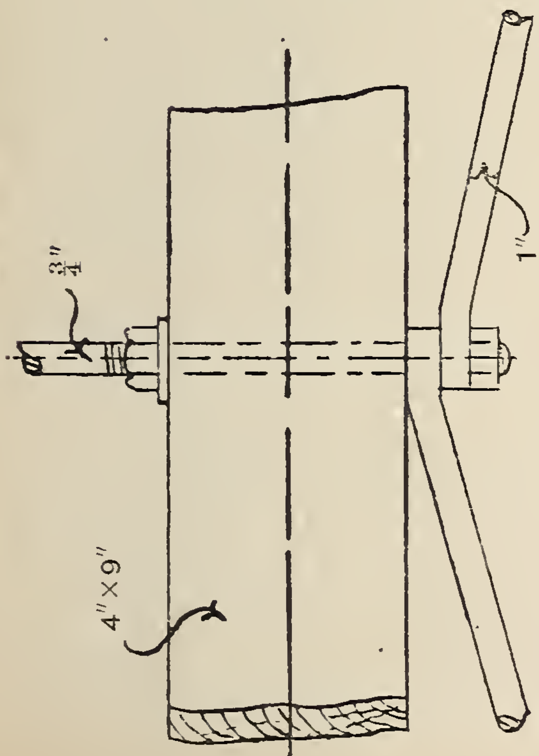


Fig. 296.

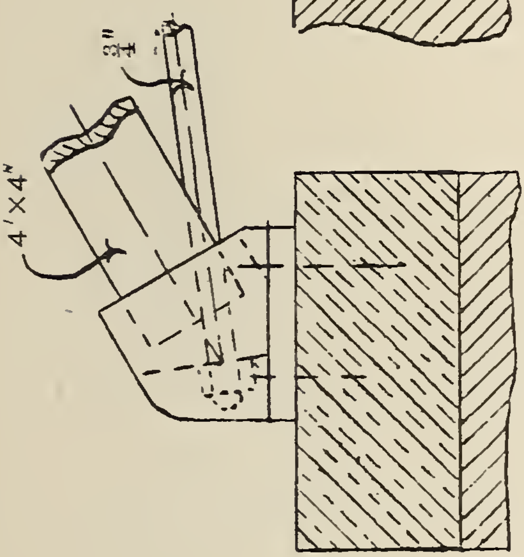


Fig. 297.

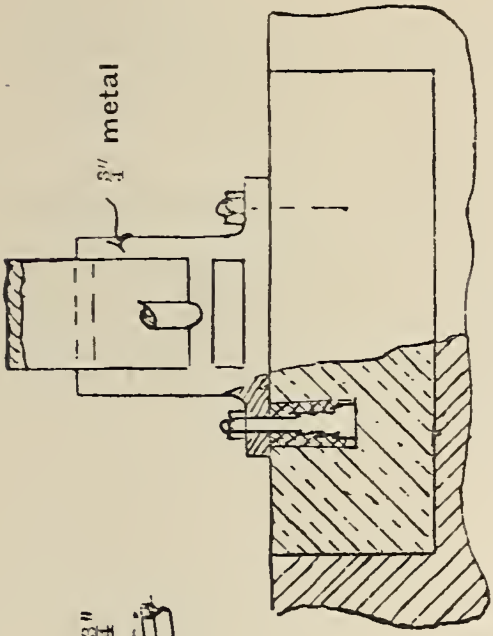


Fig. 298.

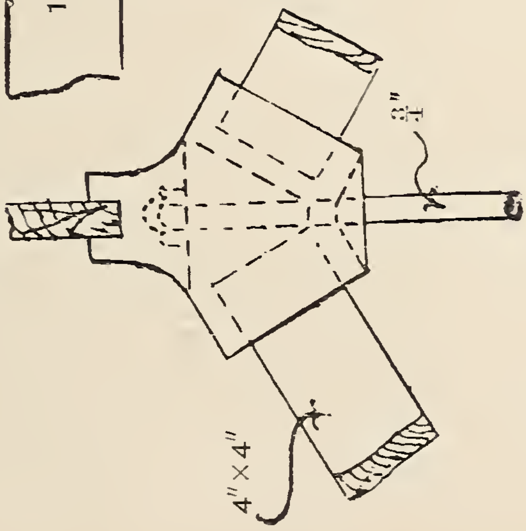


Fig. 299.

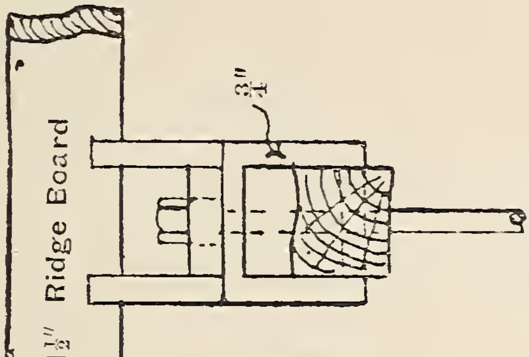


Fig. 300.

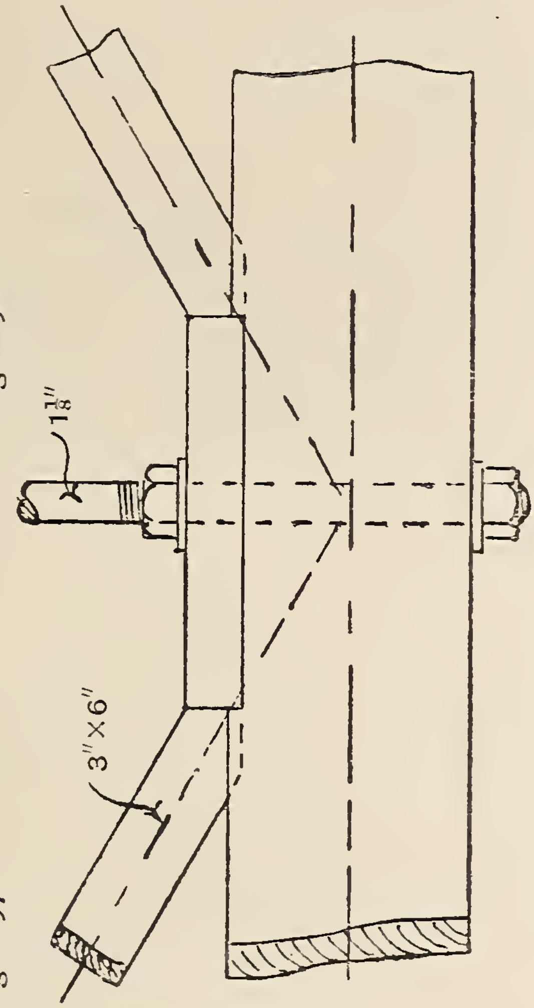


Fig. 301.

Feet of Struts.—This joint may be made by fixing a straining piece, as shown in figure 301, timber struts and tie-beam being used.

Feet of King or Queen Bolts.—These may pass through the straining pieces, which are indented into the tie-beam and receive the wood struts. The tie-beam is secured by screwed nuts and washers on king bolt over straining piece and under tie-beam, as illustrated in figure 301.

CHAPTER X.

IRON ROOFS.

Iron Roofs.—The great superiority of iron and mild steel over timber in stress-resisting properties, the great varieties of economical and suitable sections in the market, the ease with which they can be packed and transported, and their resistance to fire and insects, have caused them to gradually displace timber as materials for roofs of large or even moderate dimensions, and great attention has been given to the most economical methods of designing same.

Strains on Trusses.—Every member of a truss should be in either direct tension or compression ; but in smaller roofs the purlins are often distributed along the length of a principal rafter, causing it to be in transverse strain ; in that case the distance between struts should not be great, otherwise the principal rafter will have to be uneconomically large. Struts should be arranged as short as possible, and as many braces as possible be in tension.

Cast Iron can be advantageously employed for shoes and short struts.

Wrought Iron and mild steel are sometimes employed for every part of the truss, as illustrated in figs. 308 to 315.

Mild Steel is used for every part for which wrought iron may be used, but with reduced sections.

Riveting and Bolting.—In making the connections with members, rivets may be employed up to 1 inch in diameter, but where a larger diameter is required bolts are used; the latter are more expensive, but have the advantage of allowing the roof to settle somewhat, and the joints to adjust themselves under the load.

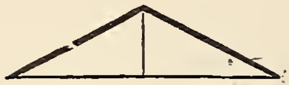


Fig. 302.
Span 15 ft. to 20 ft.

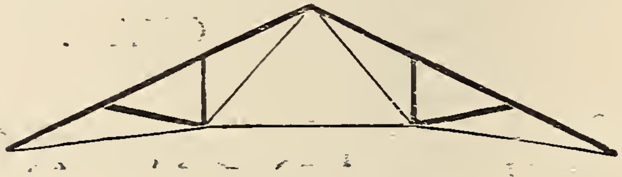


Fig. 305.
Span 30 ft. to 40 ft.

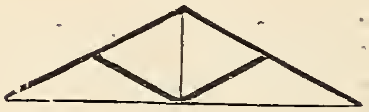


Fig. 303.
Span 20 ft. to 30 ft.

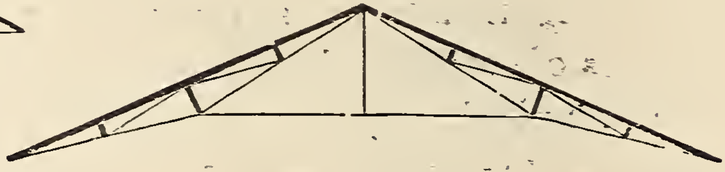


Fig. 306.
Span 40 ft. to 50 ft.

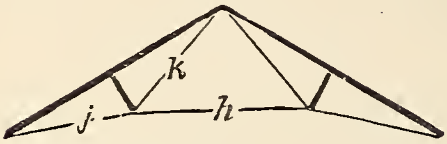


Fig. 304.
Span 20 ft. to 30 ft.

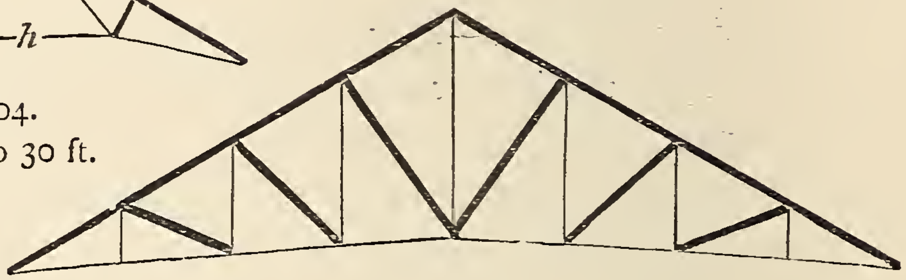


Fig. 307.
Span 40 ft. to 50 ft.

Typical Trusses.—Figures 302 to 307 show outlines of iron trusses for spans, varying from 15 to 50 feet. Thin lines indicate the members in tension, thick lines in compression.

The following table gives the dimensions of heads and

Iron Roof Truss for 20 ft. Span.

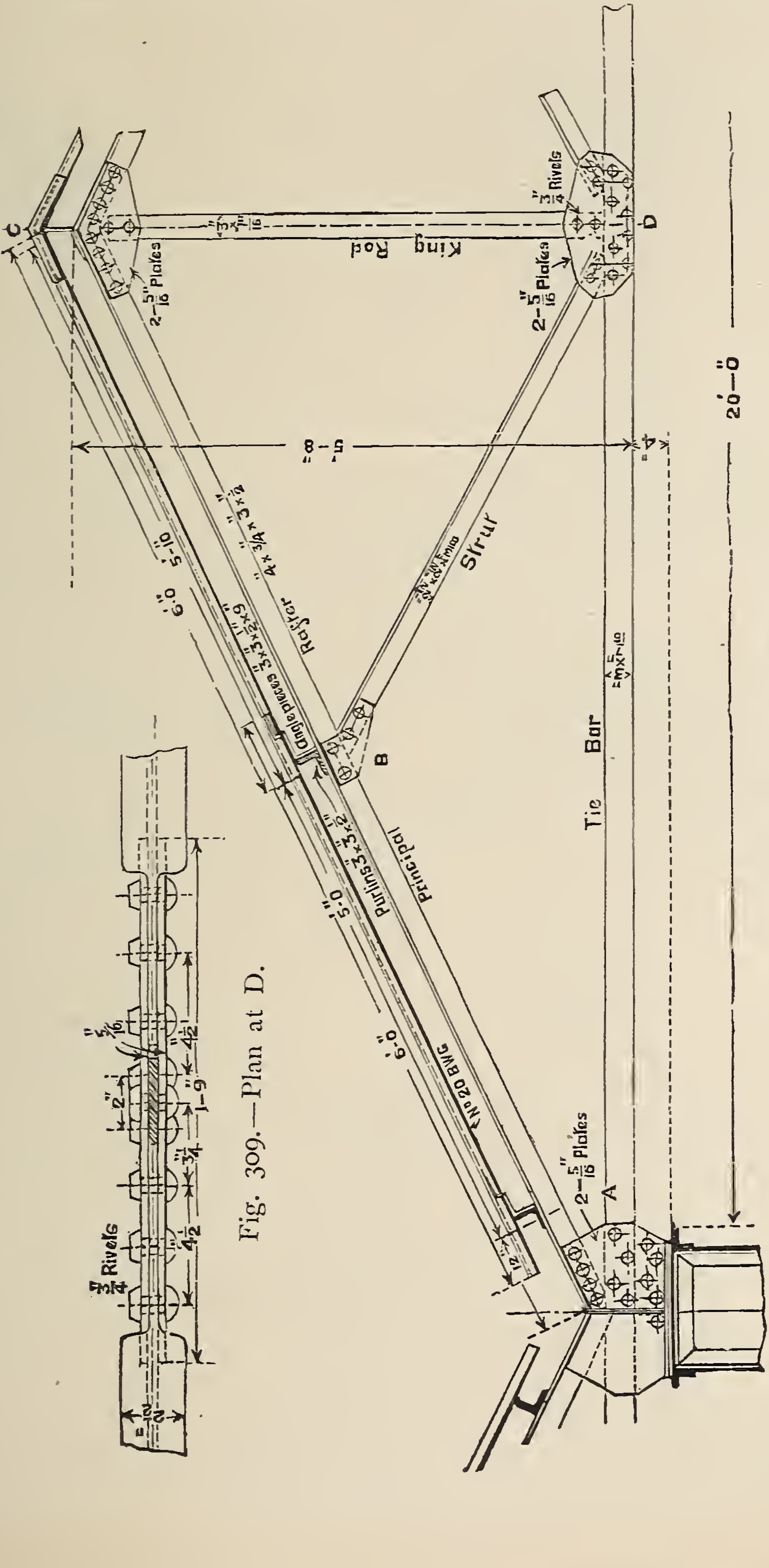


Fig. 309.—Plan at D.

Fig. 308.—Half Elevation.

Fig. 314.—Elevation at A.

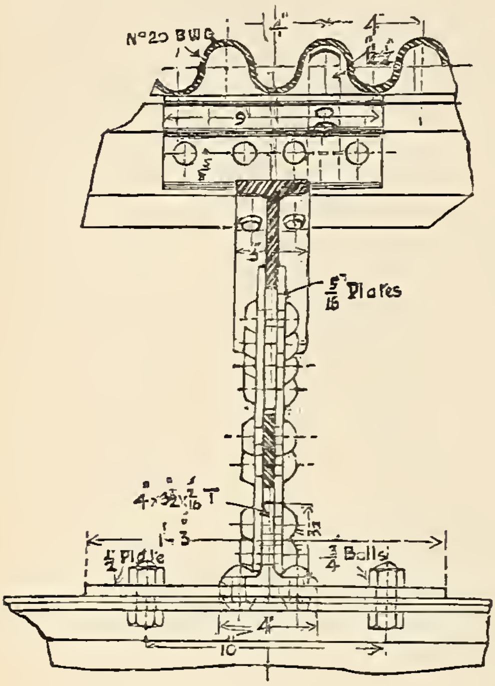
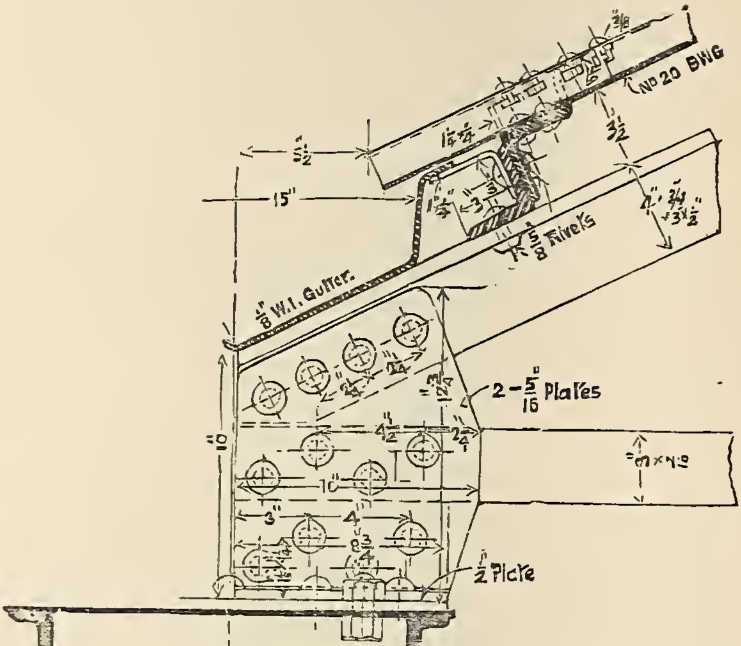


Fig. 312.—Detail at A.



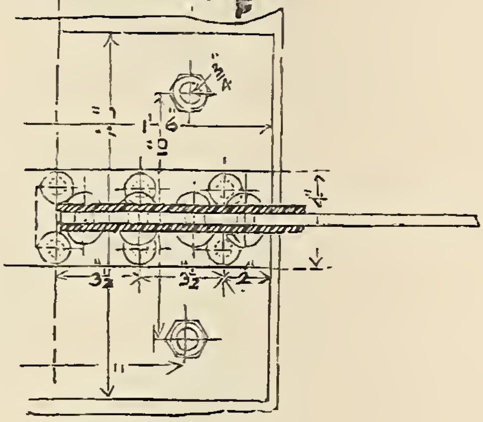


Fig. 313.

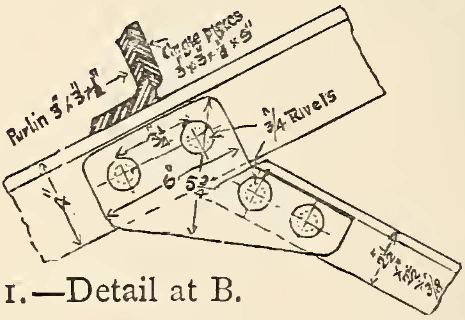


Fig. 311.—Detail at B.

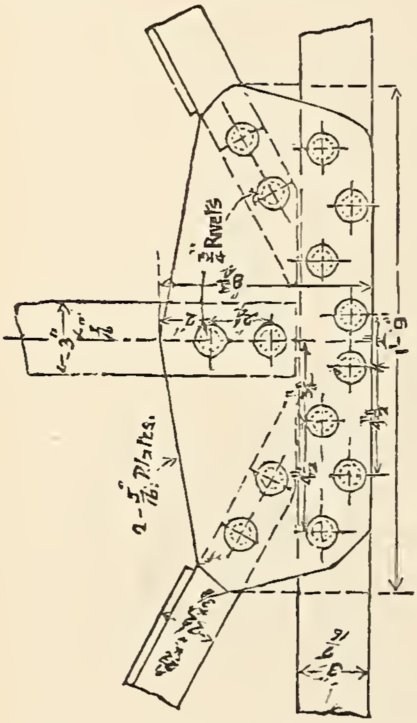


Fig. 310.—Detail at D.

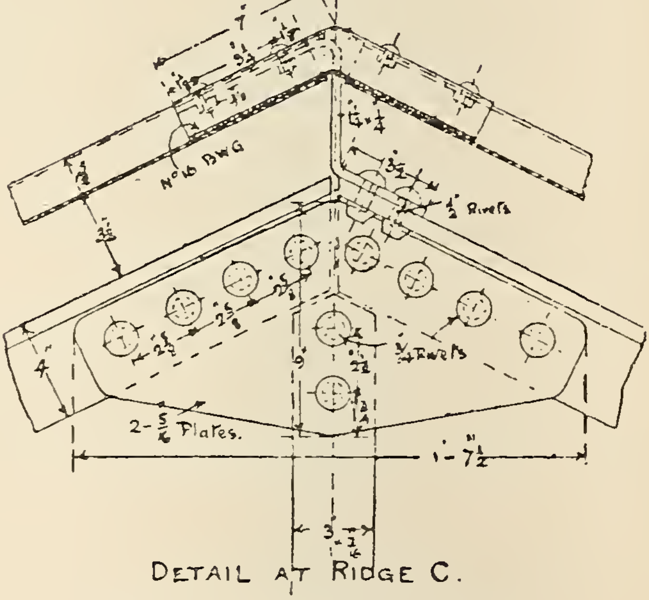


Fig. 315.—Detail at Ridge C.

Iron Roof Truss for 25 ft. Span.

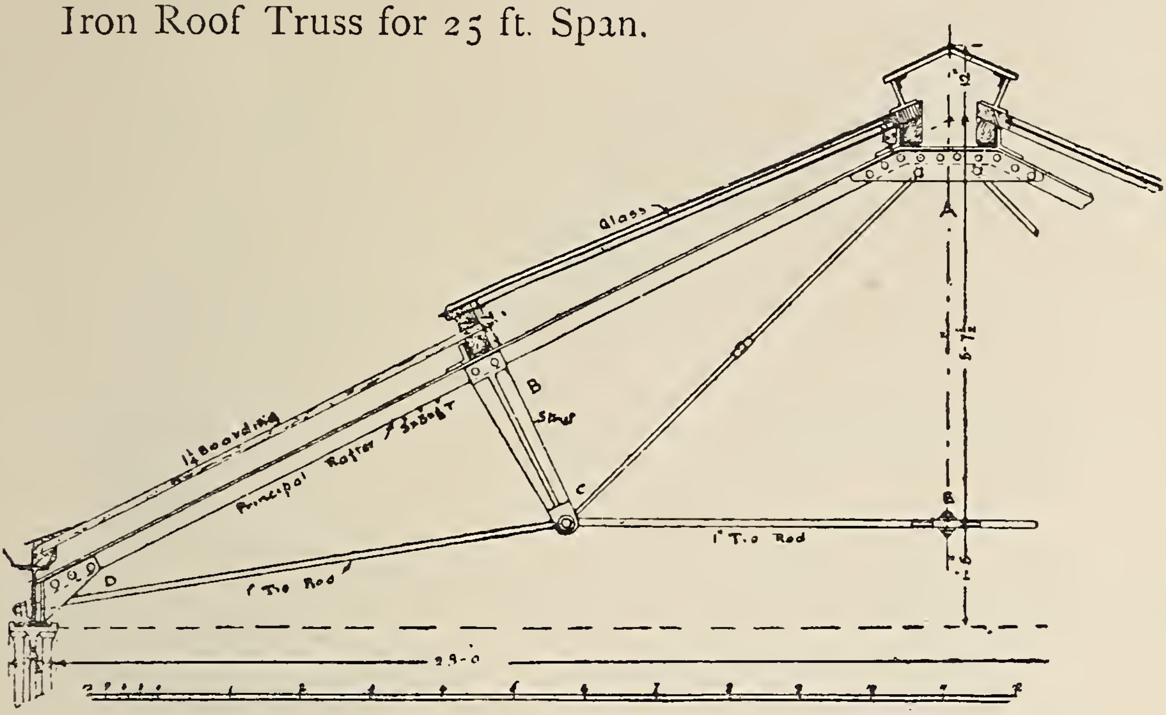


Fig. 316.

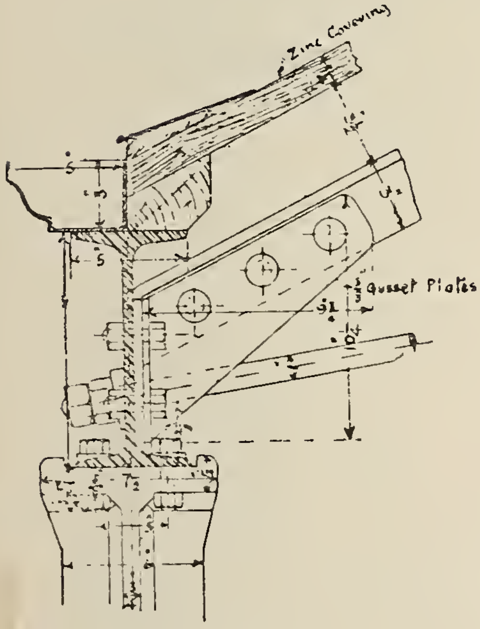


Fig. 317.

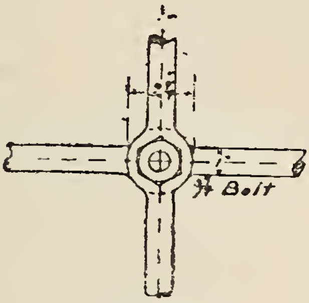


Fig. 322.

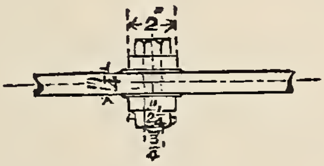
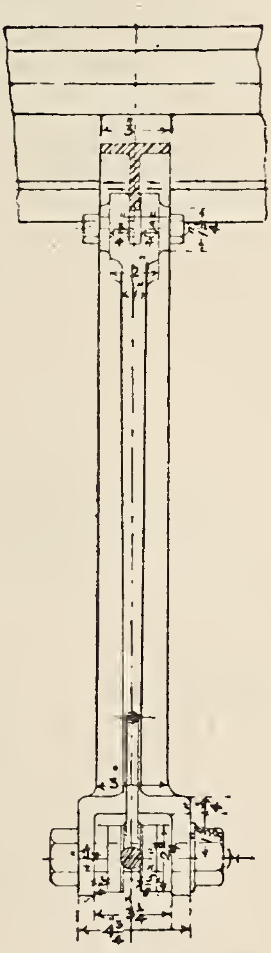


Fig. 323.



FRONT ELEVATION.

Fig. 319.

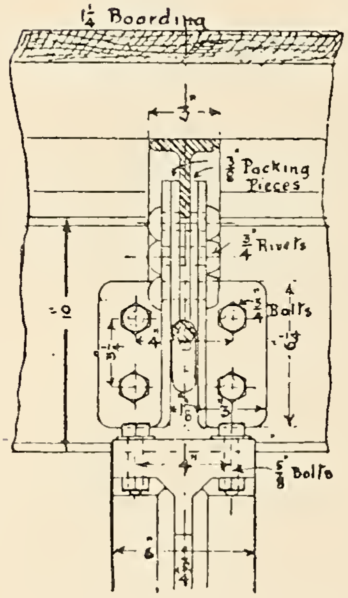


Fig. 318.

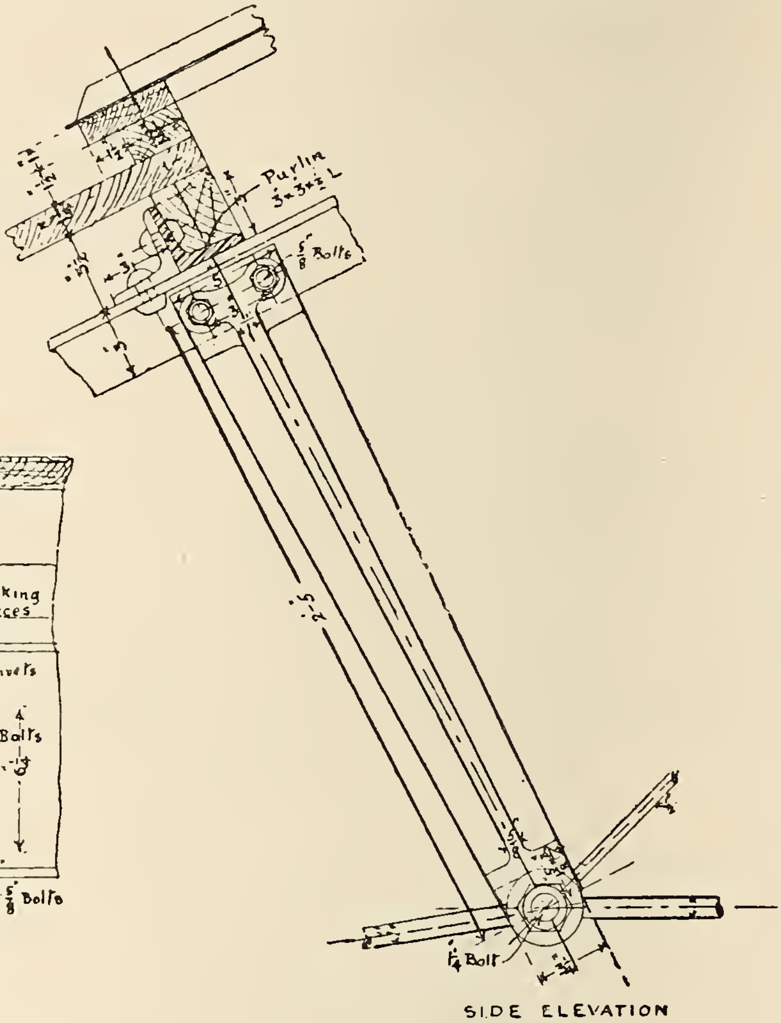


Fig. 320.—Detail at B.

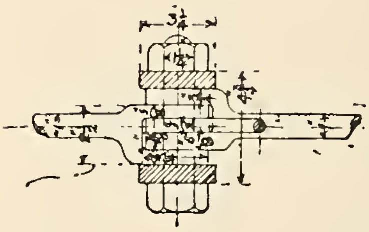


Fig. 324.
Detail at C.

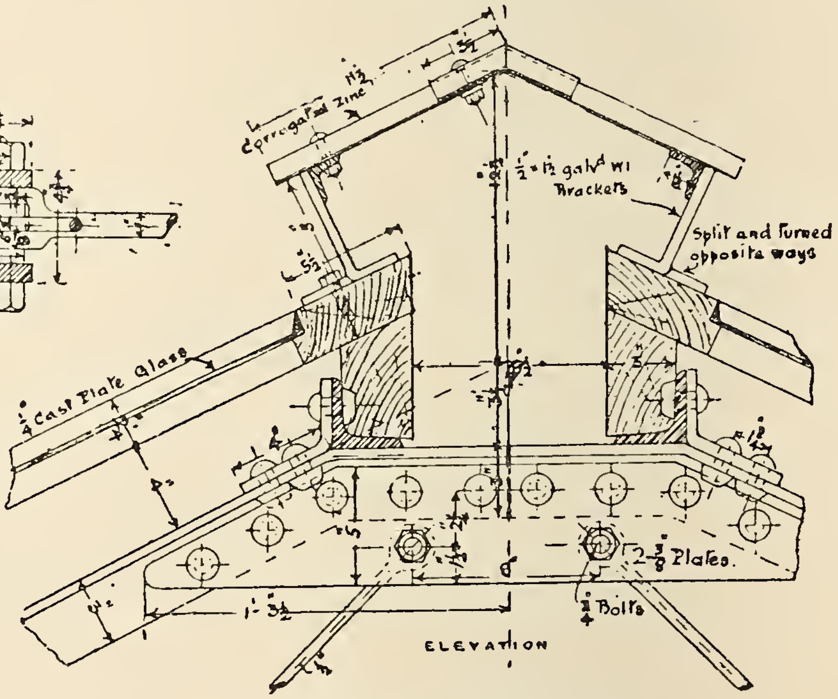
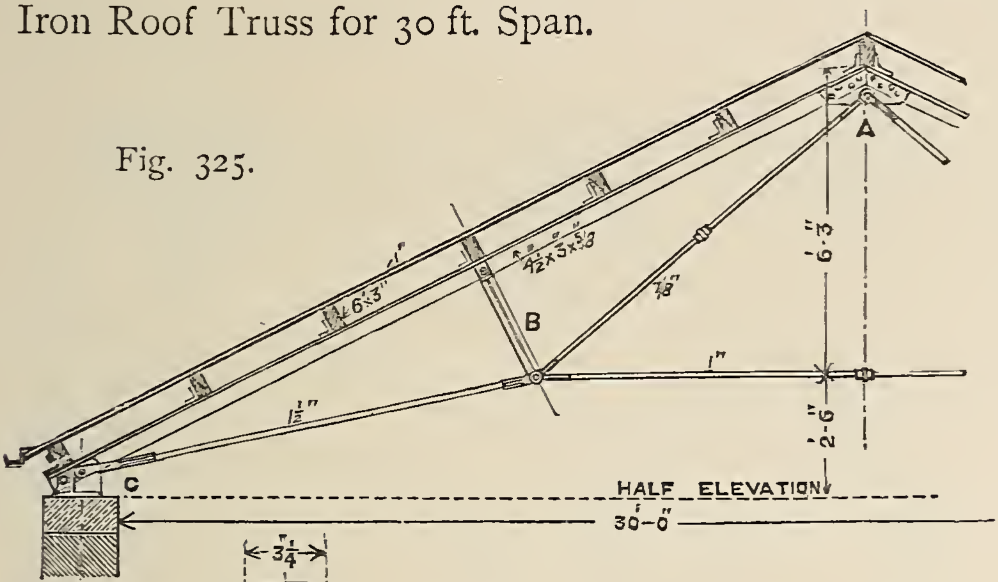


Fig. 321.—Detail at A.

Iron Roof Truss for 30 ft. Span.

Fig. 325.



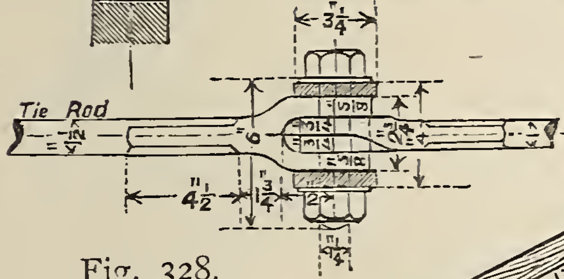


Fig. 328.

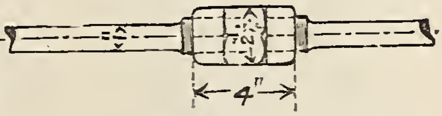


Fig. 329.

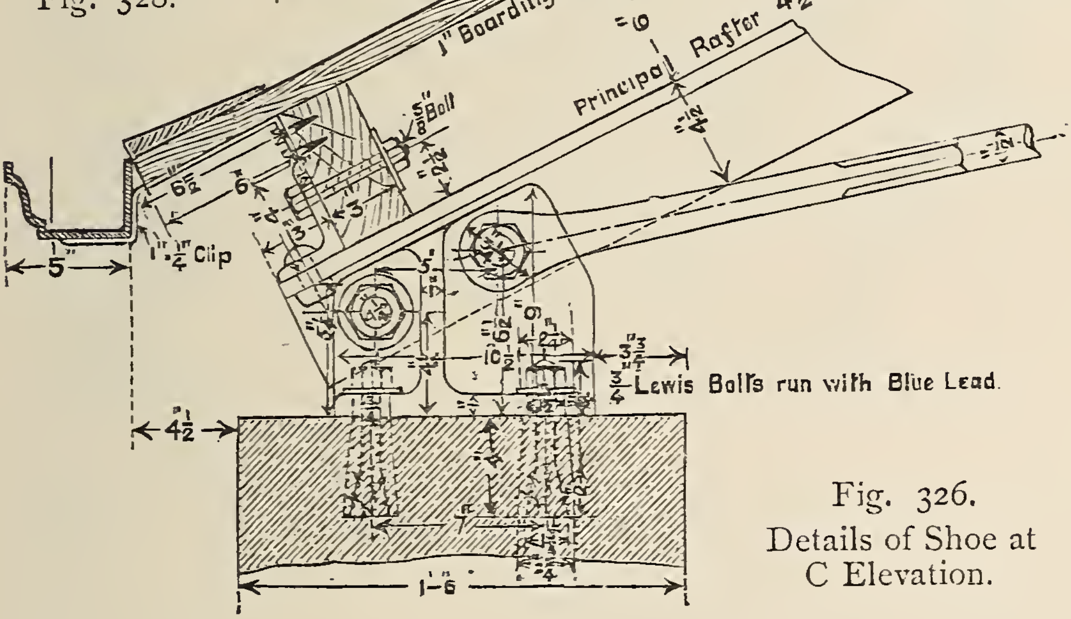

1" Boarding
6"
Principal Rafter 4½"×3"×⅝"
4½"
⅝" Bolt
6½
6
4
3
1"·¼" Clip
5"
4½
10½
6½
3¾"
¾" Lewis Bolts run with Blue Lead.
1'–6"

Fig. 326.
Details of Shoe at
C Elevation.

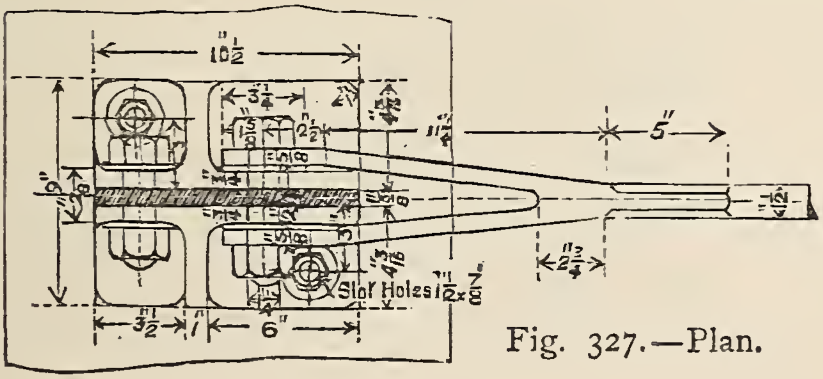


Fig. 327.—Plan.

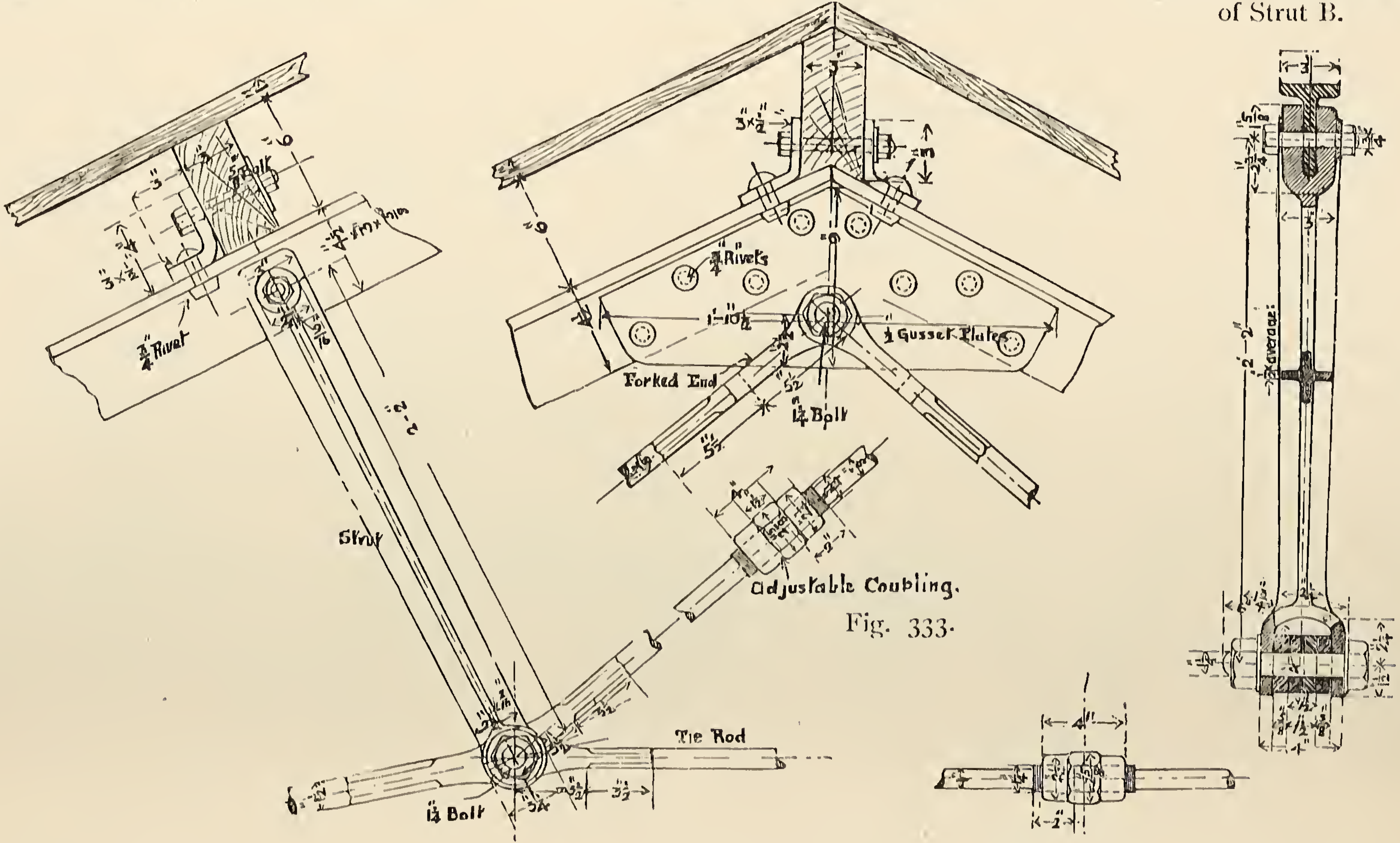


Fig. 330.—Detail of Strut and Purlin B.

Fig. 332.—Detail at Ridge A.

Fig. 331.—Side Elevation of Strut B.

Fig. 333.

Fig. 334.

nuts of square and hexagon bolts in the ratio of the diameter of the bolt:—

	Diameter of Head and Nut between Faces.	Diameter of Head and Nut across Angles.	Thickness of Head.	Thickness of Nut.
Hexagon	1·75	2	·75 to 1	1
Square	1·5	2·12	·75 to 1	1

The following table gives the dimensions of the various rivet heads in the ratio of the diameter of the shank:—

	Diameter of Head.	Thickness of Head.
Cup	1·7	·6
Countersunk...	1·6	·4
Pan head	1·6	·7
Conical	2	·75
Conoidal	2	·7

Hipped Roofs.—Trusses with perpendicular members are considered better for the trusses of hipped roofs.

Sections to resist Tension may be round or one or more flat bars, with their greatest dimensions vertical, which form has the advantage of sagging or deflecting less under its own weight.

Sections to resist Compression.—Angle iron, tee iron, and channel iron are generally used. Double channel iron, kept apart by pipe distance pieces with small bolts passing through and riveted at ends, forms a stiff section, but is more costly than tee iron. Angle irons kept in a similar manner render the connections easy to make. Flat-bar iron kept apart by distance pieces so arranged as to bulge them out in the centre and kept together by riveted bolts, form a good and simple joint, as shown in figure 336. Short struts may be made of cast iron of cross section with forked ends, as in figures 330 and 331, for a bolt to pass through and form the connection.

Sections under Transverse Strain.—Rolled iron joist, as in figure 349, angle and tee irons, are used for purlins, as in figure 308.

Pitch of Iron Roofs.—The pitch usually adopted for small roofs is $\frac{1}{4}$th, and for large $\frac{1}{5}$th the span, but this is sometimes governed by the nature of the covering. Where an occasional leak is of little importance, the lesser pitch may be used.

Camber of Tie Rods.—Tie rods are usually cambered $\frac{1}{30}$ to $\frac{1}{40}$ the span, but in some cases more. This is done to reduce the length of the struts and to gain greater height above the floor level.

Coverings of Iron Roofs.—Corrugated iron, as in figure 314, especially where the storing of the rainfall is a matter of great importance. Slates, zinc, and glass, as illustrated in figures 327 and 321, are usually the coverings employed for iron roofs.

Tightening up Joints of Trusses.—Tension or tie rods are drawn tightly up or slackened by means of gibs and cotters, as in figures 351 and 352, or by adjustable screw couplings or union joints, as in figure 333. In the latter case the tension rod is in two pieces, the adjoining ends of which are thickened and screwed with right and left handed threads; the rotation of the coupling piece then draws the ends together or urges them farther apart.

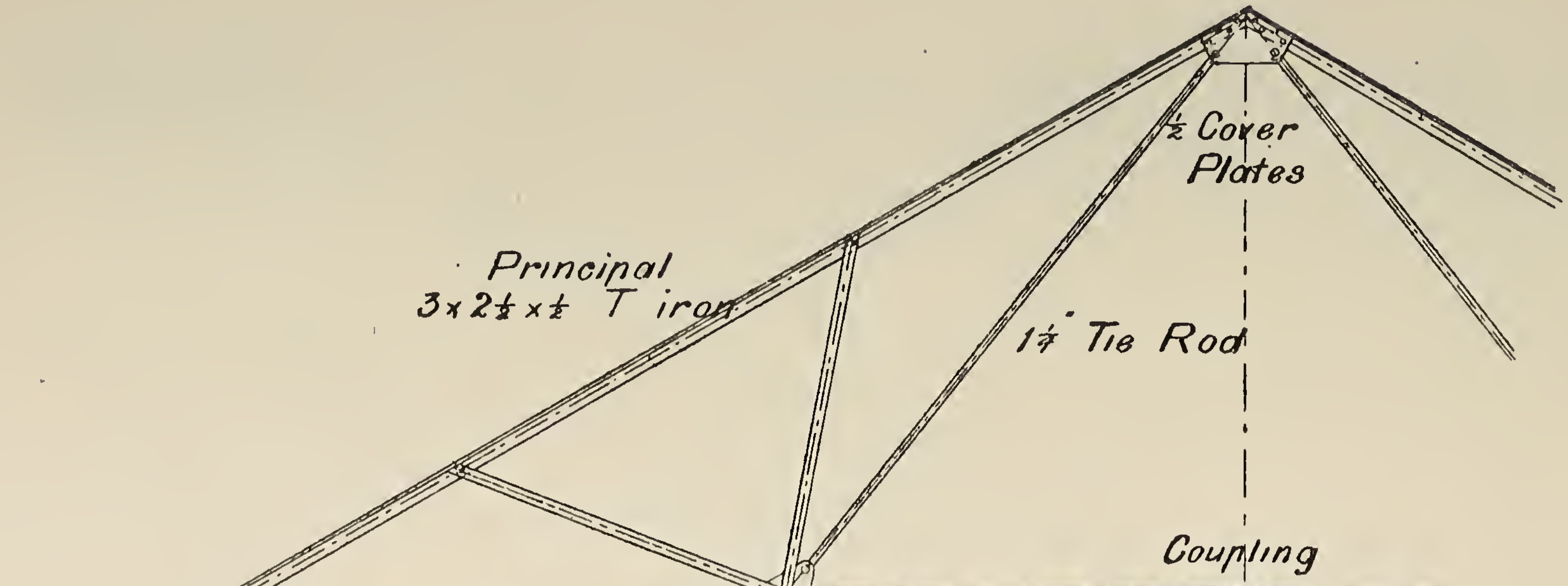


Fig. 335.

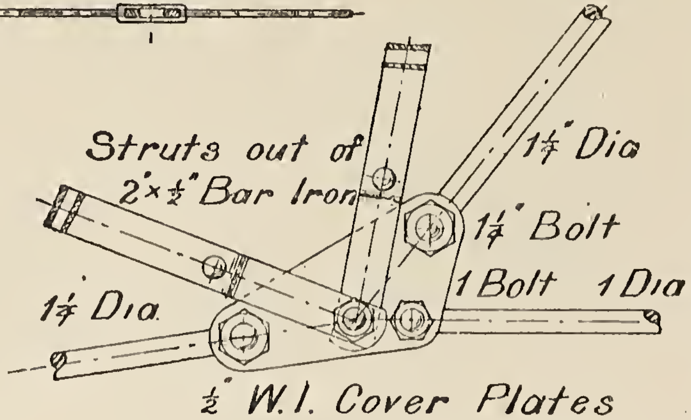


Fig. 336.

Iron Roof Truss for 40 ft. Span.

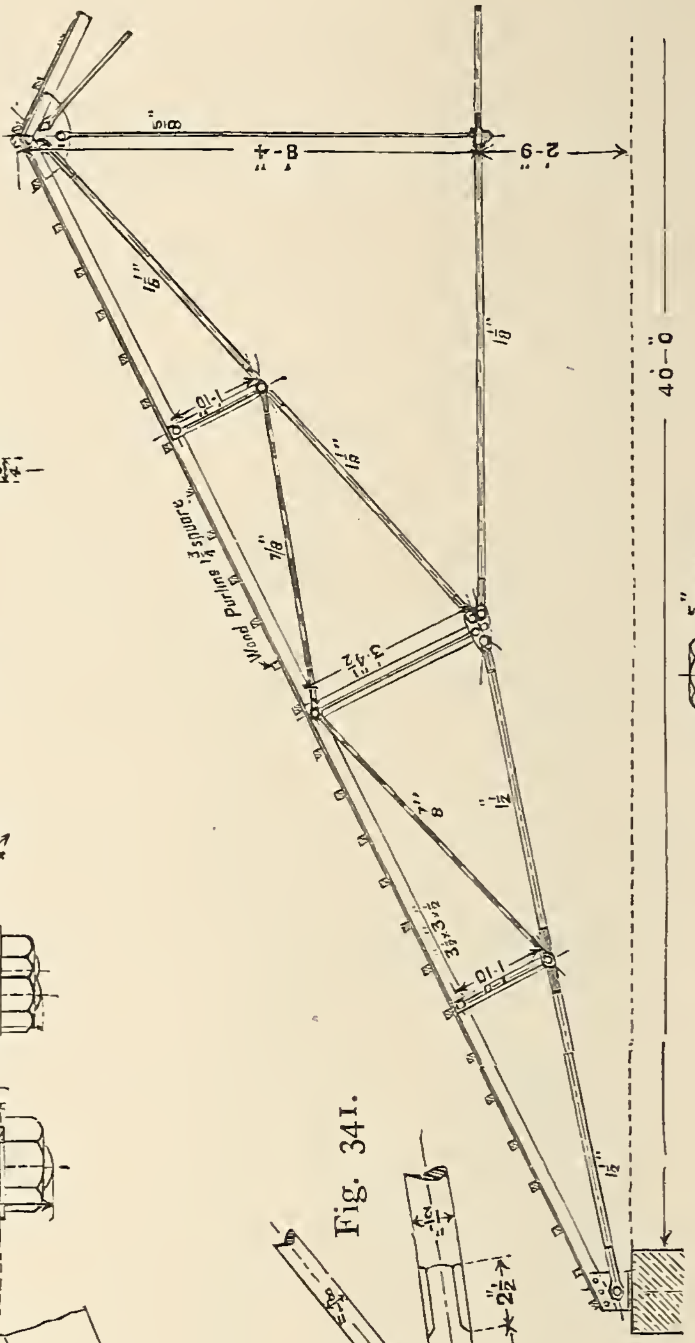


Fig. 337. Half Elevation.

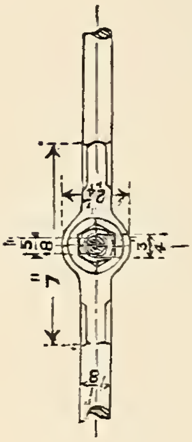


Fig. 345.

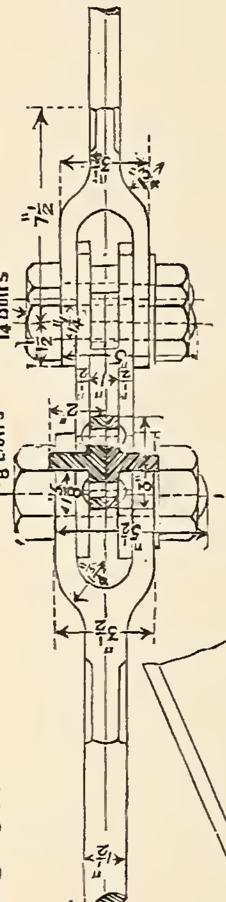


Fig. 344.

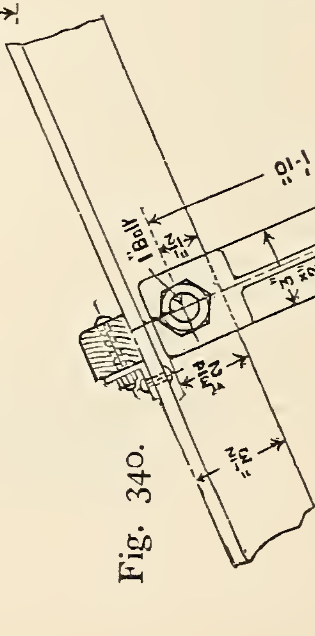


Fig. 340.

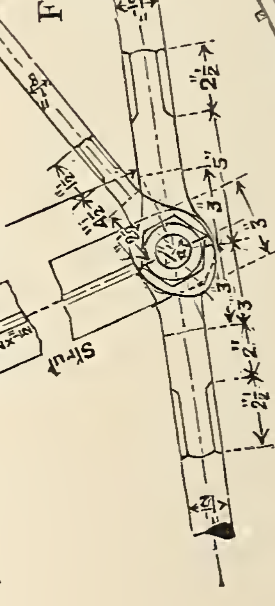


Fig. 341.

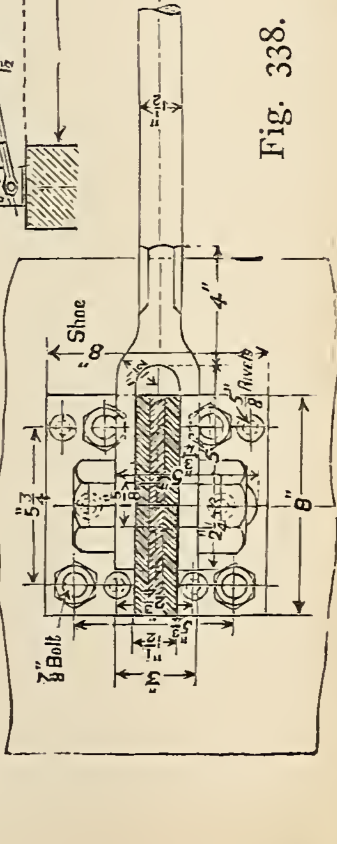


Fig. 338.

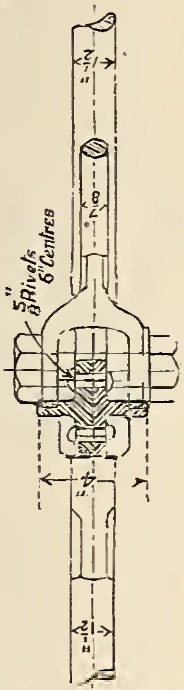


Fig. 348.

Details for 40 ft. Span.

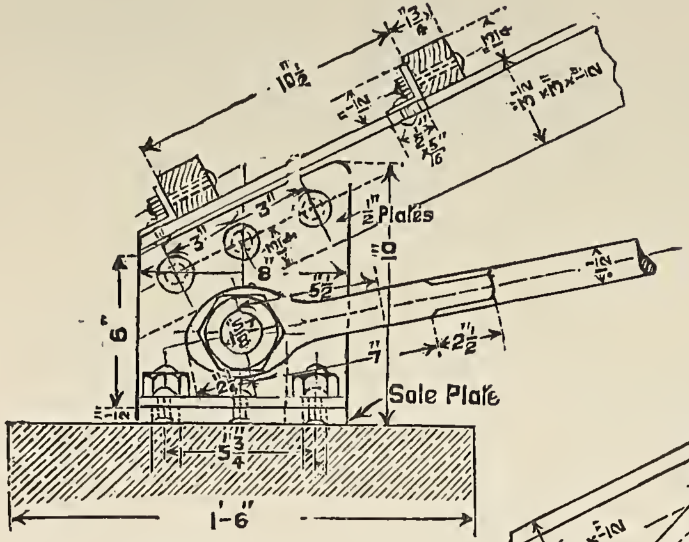


Fig. 339.

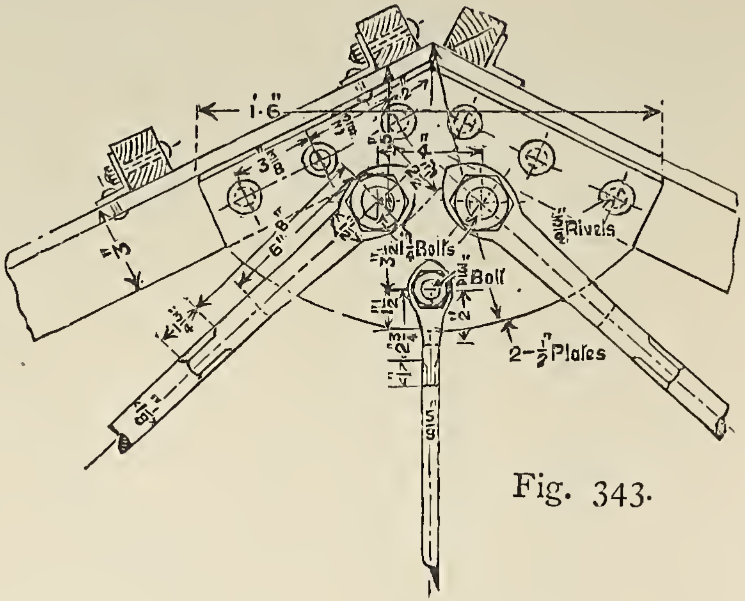


Fig. 343.

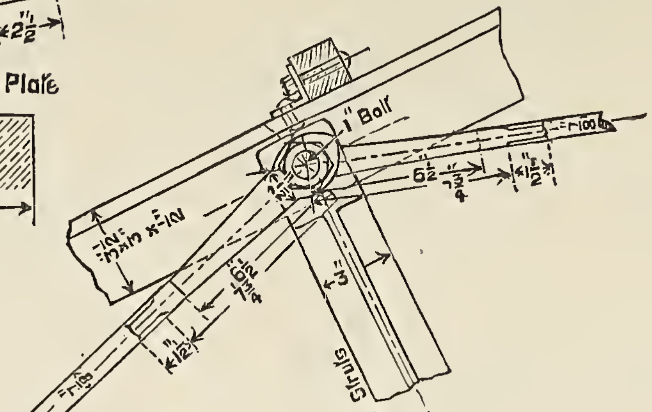


Fig. 342.

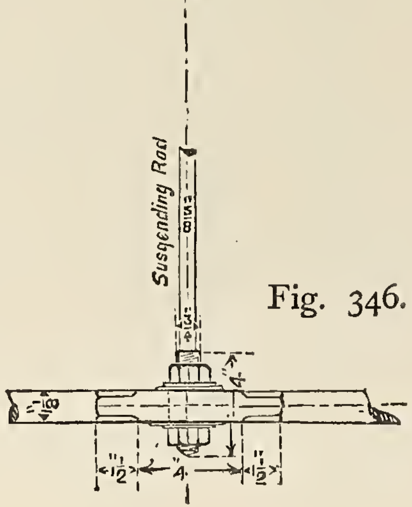


Fig. 346.

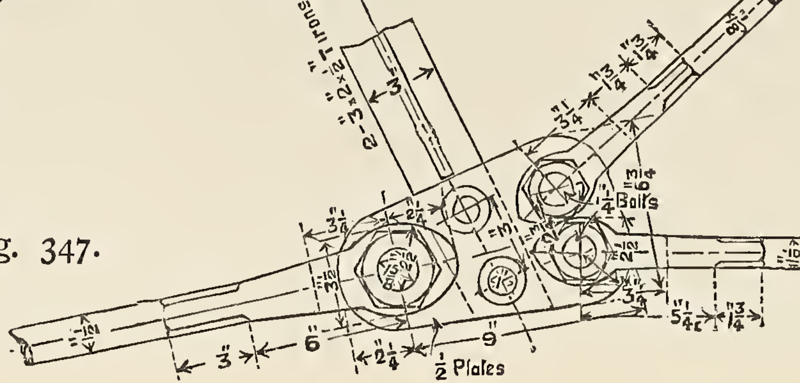


Fig. 347.

Plus and Minus Threads.—Threads worked upon thickened ends of rods are known as plus threads, and those formed on rods without thickened ends are called minus threads, as the latter reduce the diameter of the solid rod.

Design of Joints.—Joints of trusses should be designed on the fork, eye, and pin principle. The centre line of members should be drawn about each joint, all meeting in a point.

There are two general methods of construction:—1st. The interior member is constructed as an eye, as in figure 360, taking the common intersecting point as the centre, and the outer member or members forked, as in figure 361. A bolt, calculated as described in Part 2, is inserted, and acts as the common axis for all the members about the joint to rotate, as shown in figure 341.

2nd. All members are forged flat, and widened at extremities to one common thickness, or packed up to one common thickness, and eyes are drilled; two cover plates enclose same, having drilled holes coinciding with the eye holes of the members, the centre of which are in the centre lines at a distance sufficiently far from the common point of intersection to allow for the necessary width of metal about the eye hole, and a small clearance between the parts. Nutted bolts are then placed through cover plates and members. It may be noticed that a slight adjustment may cause the centre lines not to meet all in a common point, but the error is usually so small that it may be neglected. The cover plates practically act as a common fork, and the enclosed struts and ties as a number of eyes, as shown in figure 336.

It may be noticed that various changes may be introduced; thus, the cover plates may be designed to enclose a thin flat member, as the web of a strut, and to act as the eye piece part, the adjoining members being forged as forks, as shown in figure 359, but this is needlessly expensive.

Iron Roof Truss or 50 ft. Span.

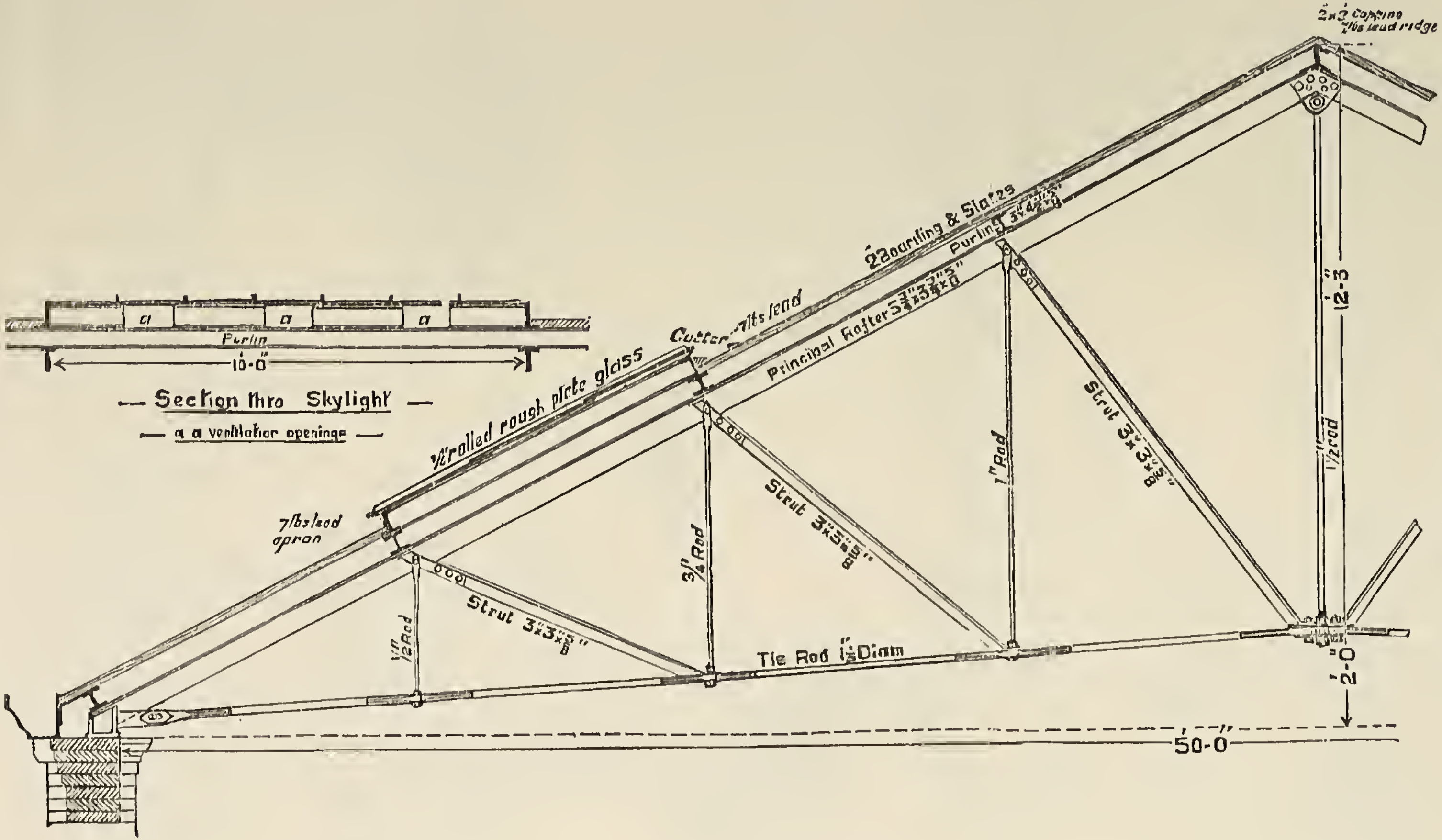


Fig. 349.

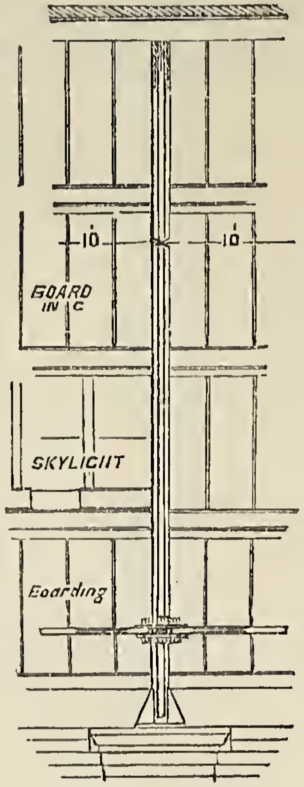


Fig. 350.

Junction at Feet of Principal Rafters.—These may be constructed by riveting cover plates over web of principal rafter and flat tie rod, as shown in figure 308, by forking tie rod over web of principal rafter and shoe, as in figures 326 and 327, or by arranging cover plates to fork over web of principal and bolting in both methods to cast-iron shoe, having side cheeks cast on, to prevent the principal moving laterally. The shoes are bolted on one side of building to stone templates, and on the other by passing bolts through elliptical holes cast in shoes, as in figures 351 and 352, to allow the truss, by being free, to move at one

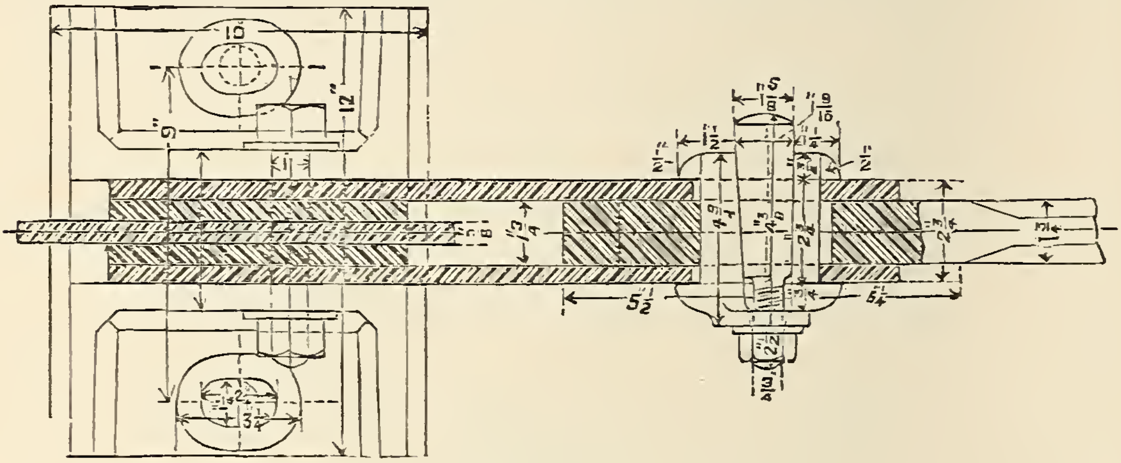


Fig. 351.

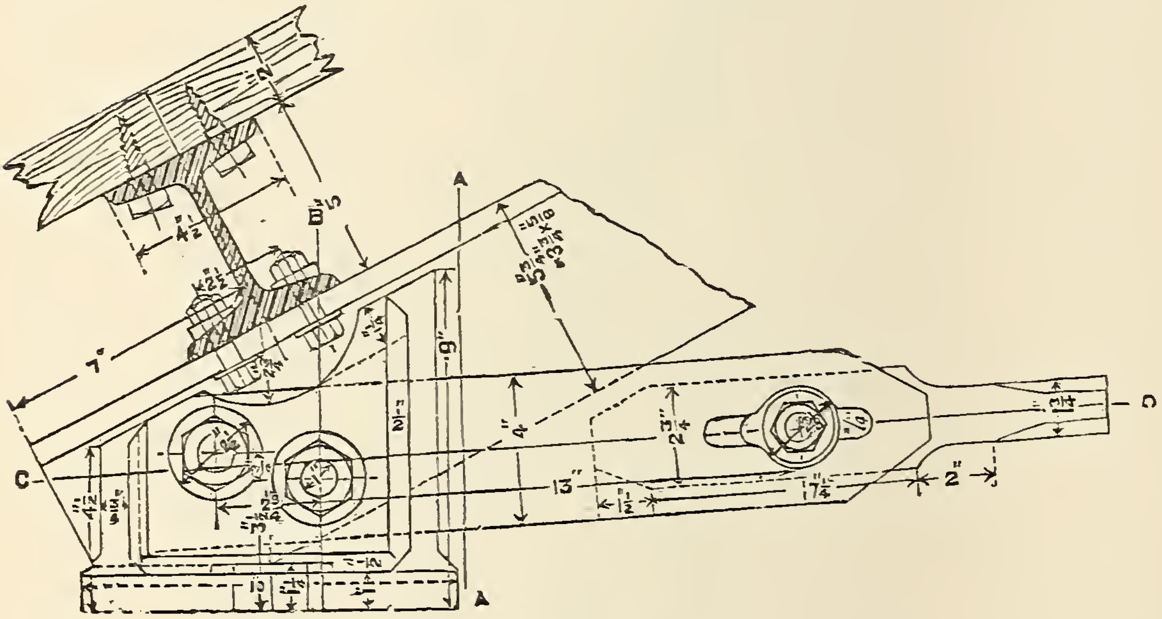


Fig. 352.

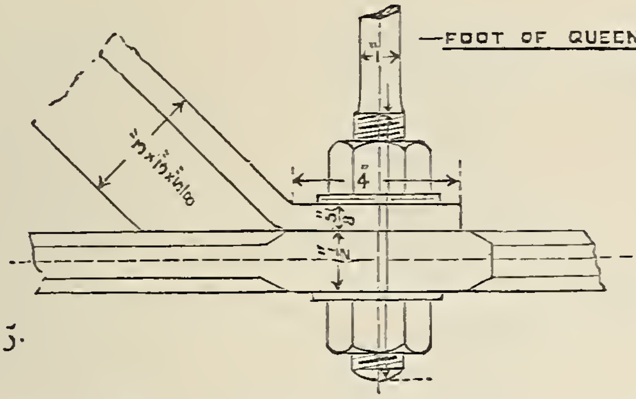


Fig. 365.

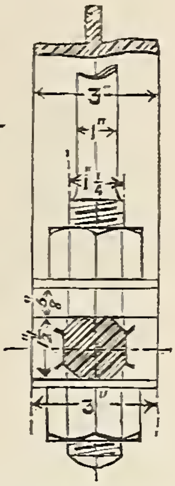


Fig. 366.

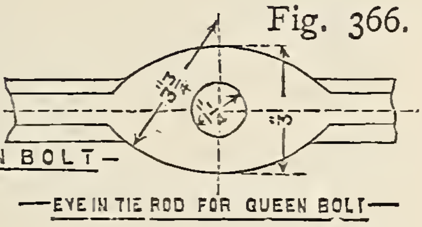


Fig. 364.

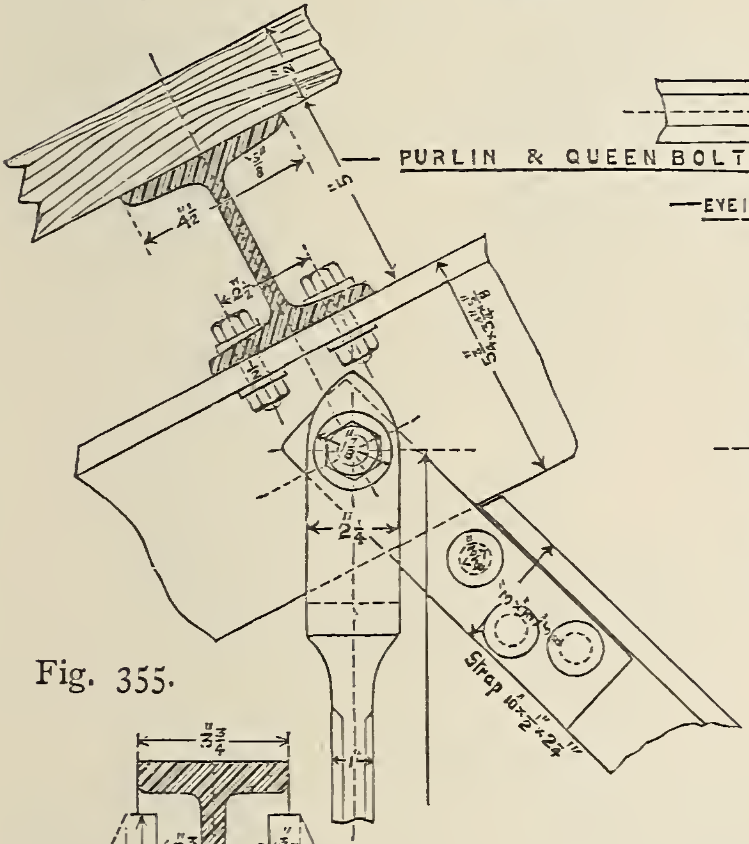


Fig. 355.

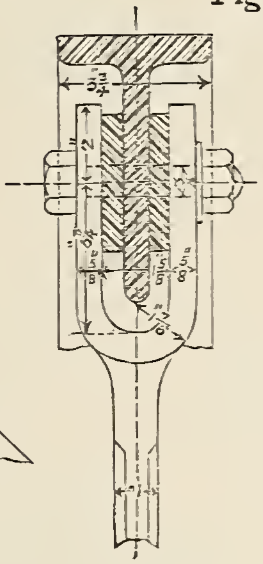


Fig. 356.

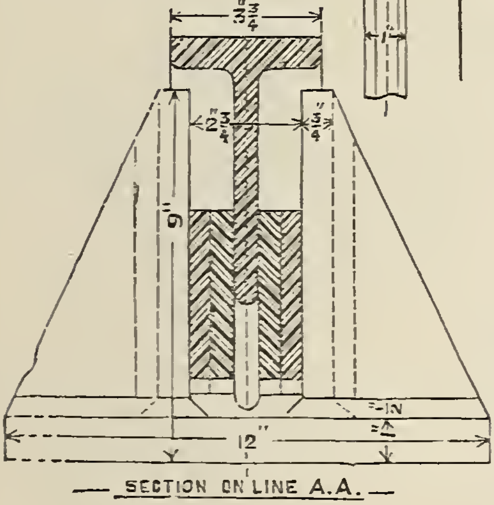


Fig. 353.

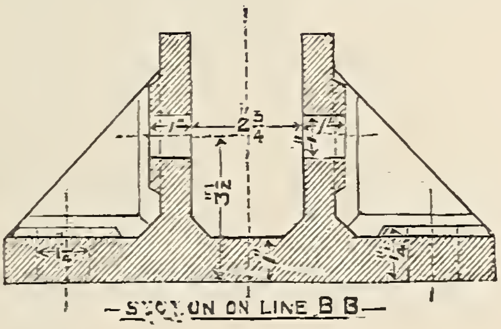


Fig. 354.

Fig. 360.

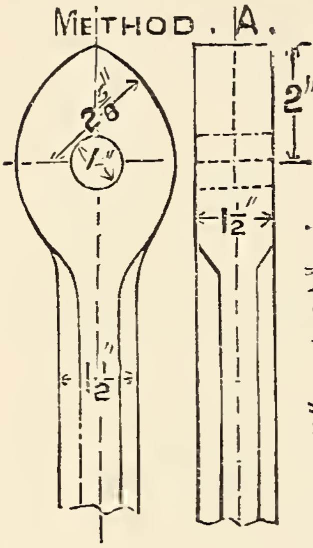


Fig. 358.

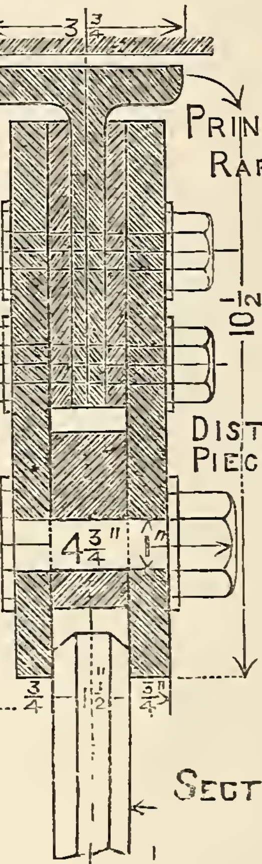
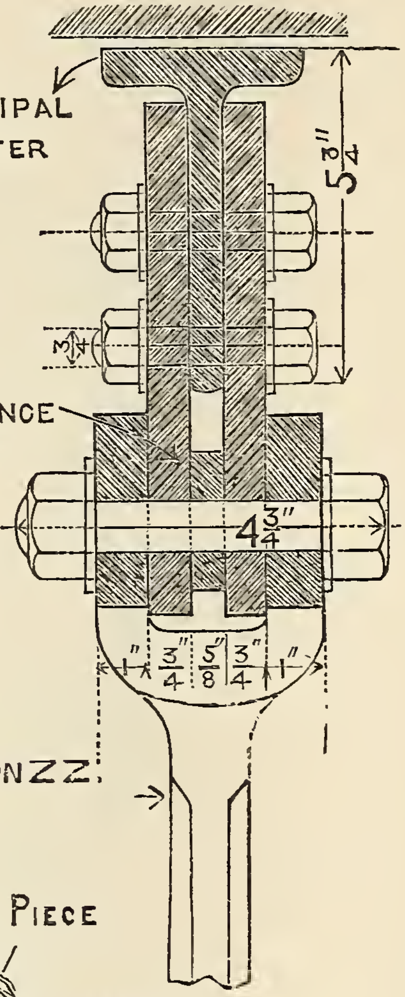


Fig. 359.



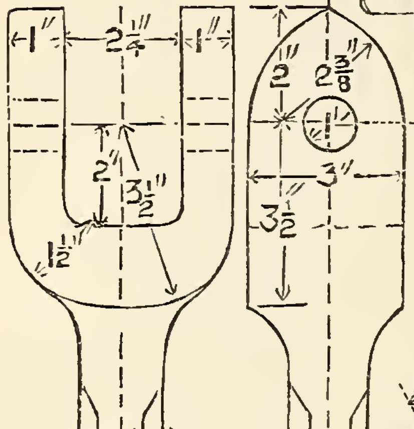
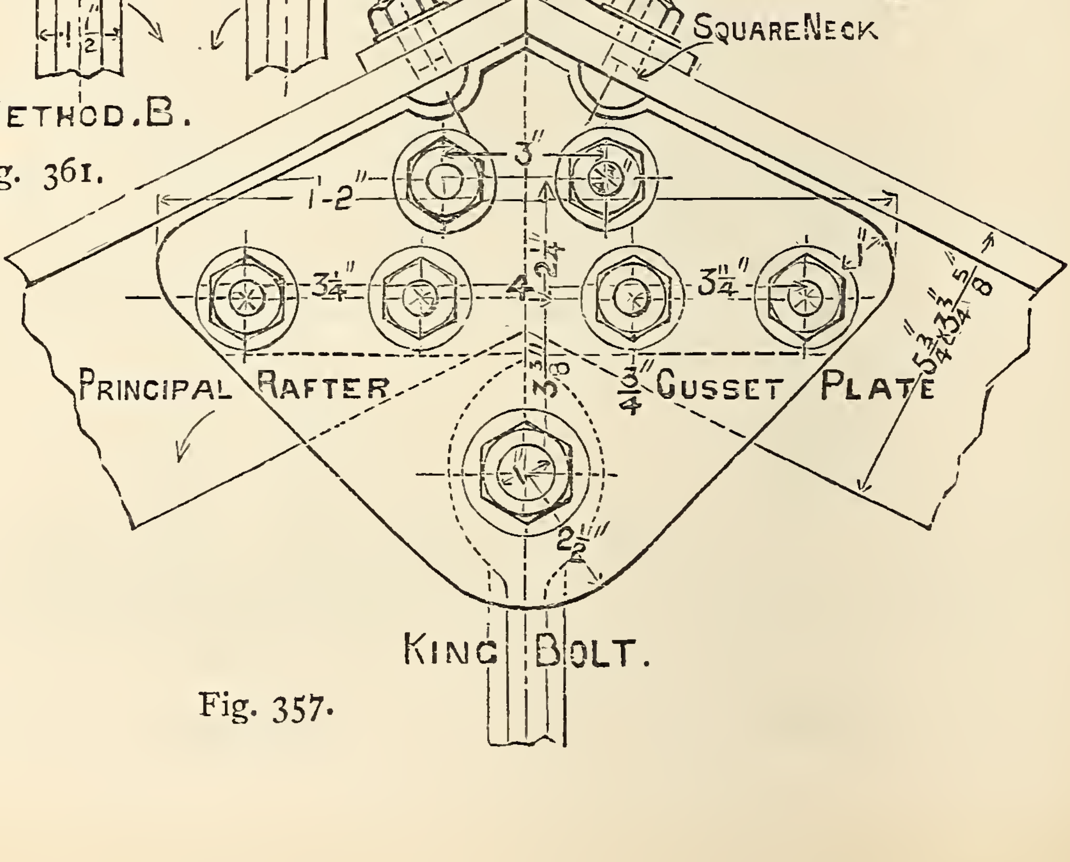


Fig. 361.



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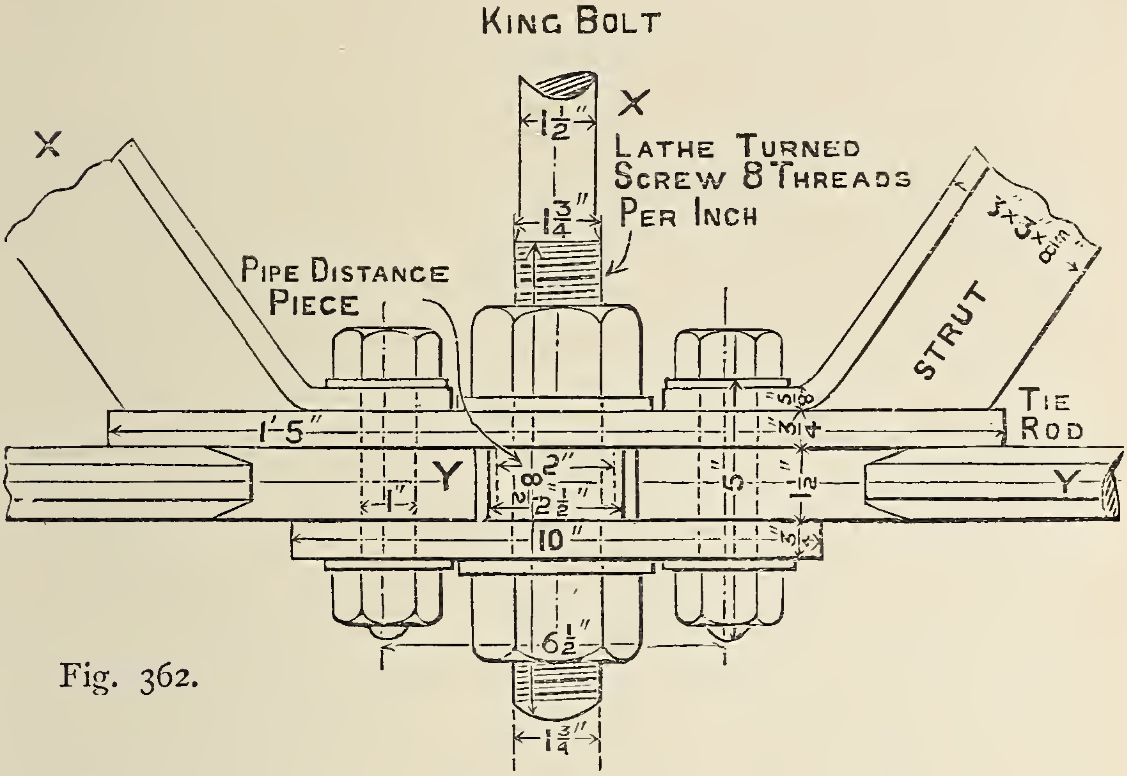


Fig. 362.

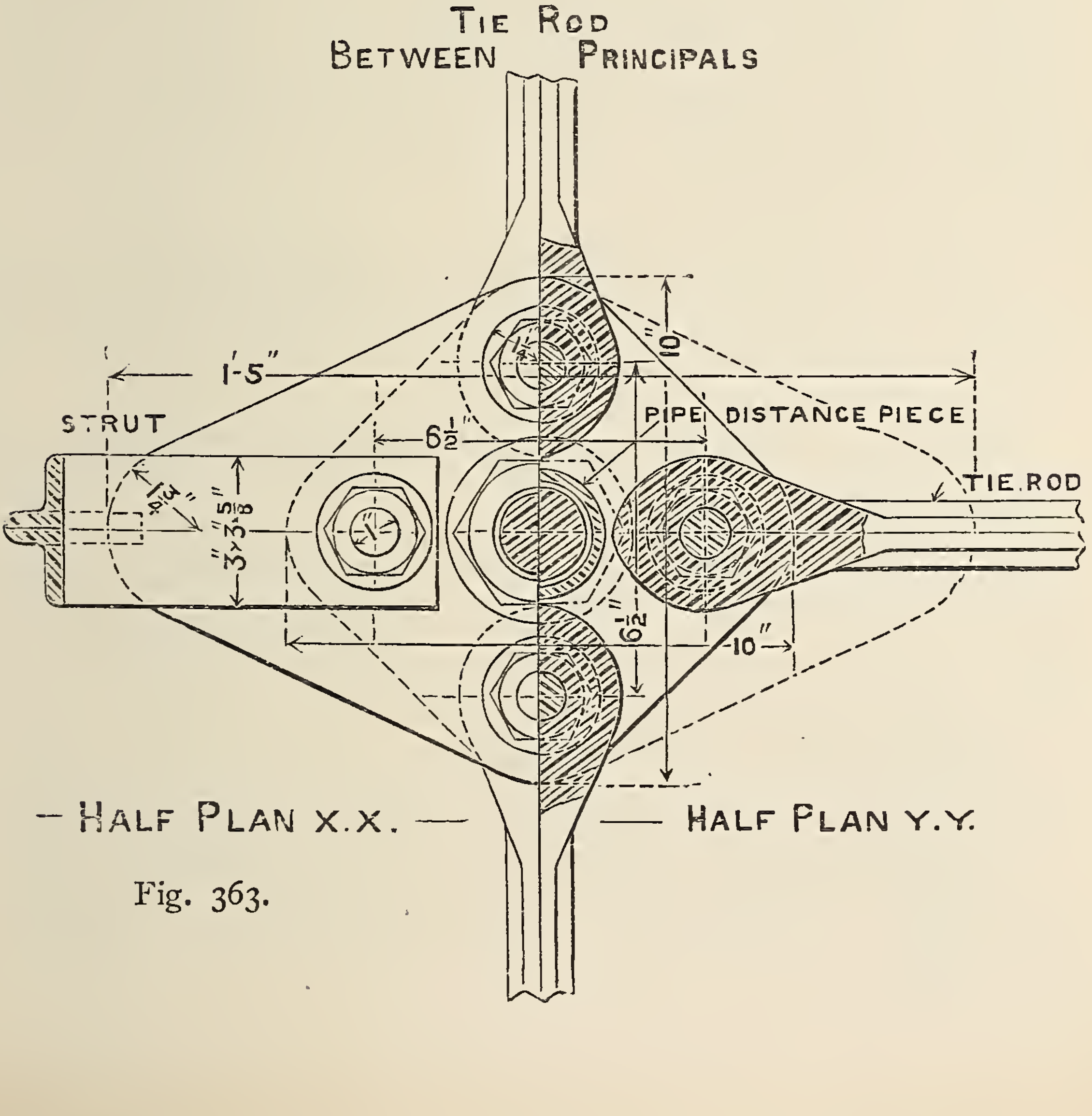


Fig. 363.

end in a horizontal direction to expand and contract under changes of temperature without hindrance.

Junction of Members at Foot of King Bolt.—These may be arranged, as shown in figures 308, by riveting to cover plates where all the members are of flat iron, or as in figures 362 and 363, which show king bolt, struts, and tie rods secured by nuts and bolts to junction plates. All trusses to prevent them bulging laterally should be tied together by rods at the feet of king bolts, as shown in figure 363.

Junction at Foot of Strut with Tension and Tie Rod.—This may be constructed with unequal forks to tie rod when in two pieces, strut forked over both, and the whole bolted together, as in figure 324, or horizontal portion ot tie rods and lower jaw of tension rods may be forged slightly eccentric and eyes drilled, the strut and lower portion of tie rod forked, and all bolted together, as shown in figure 328; or, as in the example of truss for 50 feet span, figures 362 and 363.

Junction with two Struts and Tie Rod.—This joint often occurs in small trusses about 35 feet span, and may be constructed as in figures 335 and 336.

Junctions at Heads of Principal Rafters.—These may be formed by means of gusset plates—

(*a*) With tension rods forged flat at end, and eyes drilled, and thickness of web made out with packing pieces, and the whole riveted or bolted together according to its size, as shown in figures 357 and 358.

(*b*) By forking tension bolts over gusset plates packed out with pipe distance pieces, the length of which is equal to the thickness of the web of the principal rafter, and the whole is bolted or riveted together, as shown in figure 359.

Junction of Struts with Principals.—Where cast-iron struts are used forks are cast on ends of struts for bolting to principal rafters and tie rods, as shown in figure 331; if flat bar or tee iron is employed for struts, straps are riveted to each side of the web of the struts to enclose web of principal rafter, to which it is riveted or bolted. If a tension rod is suspended from this joint it should be forked over, as shown in figures 355 and 356.

Dimensions of Members.—The following dimensions from actual practice are given in Molesworth's "Pocket Book":—

SCANTLINGS OF IRON ROOFS.—⅕ PITCH.

CAMBER OF TIE ROD = $\frac{\text{SPAN}}{40}$ PRINCIPALS 6 feet 8 inches APART.

Span.	Principal Rafter.	Struts.	King and Queen Bolts. Diam. =			Tie Rod. Diam. =		
Feet.	Tee Iron.	Tee Iron.	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*
20	2½ × 2 × ⅜	2 × 2 × ⅜	¾	⅝	—	⅝	¾	—
25	2¾ × 2½ × ⅜	2 × 2 × ⅜	⅞	¾	⅝	⅞	1	—
30	2¾ × 2½ × ½	2½ × 2½ × ⅜	1	¾	⅝	1	1⅛	—
35	3 × 2¾ × ½	2½ × 2½ × ⅜	1	¾	¾	1	1⅛	1¼
40	3½ × 3 × ½	2½ × 2½ × ⅝	1⅛	⅞	¾	1⅛	1¼	1⅜
45	4 × 3½ × ½	3 × 3 × ½	1¼	1	⅞	1¼	1¼	1⅜
50	4 × 3½ × ⅝	3 × 3 × ⅝	1¼	1	⅞	1¼	1⅜	1½
55	5 × 4½ × ⅝	4 × 4 × ½	1⅜	1⅛	1	1⅜	1½	1⅝
60	5 × 4½ × ¾	4 × 4 × ⅝	1⅜	1⅛	1	1½	1⅝	1¾

⅕ PITCH.—CAMBER OF TIE ROD = $\frac{\text{SPAN}}{30}$ (see fig. 304).

Span.	Principal Rafter—Tee Iron.	*h.*	*j.*	*k.*
20	2½ × 2 × ⅜	⅝	⅞	⅝
25	2¾ × 2 × ⅜	¾	1	¾
30	2¾ × 2½ × ½	2¼ × ¼	2¼ × ⅜	2¼ × ¼
35	3 × 2¾ × ½	2½ × 5/16	2½ × ½	2½ × 5/16
40	3½ × 3 × ½	2½ × ⅜	2½ × ⅝	2½ × ⅜
45	4 × 3½ × ½	3 × ⅜	3 × ½	3 × ⅜

Small Trusses.—Trusses up to 20 feet span are usually made without struts, simply tee iron principal rafters and flat or round iron for tie and king bolts, or with corrugated iron overlapping, and riveted together in the form of an arch, and prevented from springing by the tie forming the chord of the arch.

Elevation of Trusses.—Up to 30 feet span, trusses may be formed by T-iron principals, and flat bar for tensional members, the joints held together by riveting to cover plates.

Figures 340 to 347 show a method of forming trusses suitable for spans of 40 feet, using round bar iron for tensional members, T-iron for principals, and cast or wrought iron of cross section for struts.

Figures 317 to 327 give all necessary details and methods of securing shoes to cast-iron stanchions or to stone templates, and method of forming ventilators at apex. The truss for 30 to 40 feet spans is sometimes economically arranged by using two cast-iron struts, which are supported at junction of tension and tie rods, and in their turn uphold the principal rafter. Figures 335 and 336 show method of arranging the junction of the five members.

Forty feet to 50 feet spans may be roofed, as illustrated in figures 337 to 348, which is known as the Belgian truss, or, as in figures 349 to 363, which illustrates an English truss, with method of constructing skylight, and obtaining ventilation.

CHAPTER XI.

JOINERY.

Definition.—Joinery is the art of preparing and framing pieces of timber together to form the finishings of houses, and comprises all wood-work fixed for decorative purposes, as well as for convenience or utility, apart from structural work.

Design of Joinery.—Joinery is not required to resist great stresses as in the case in carpentry works, appearance, not strength, being the primary consideration; all the skill of the joiner is therefore expended in constructing the work in such a manner that it shall resist deterioration.

There are three ways in which joinery becomes defective. First, by the warping or splitting of the material; secondly, by the joints coming apart owing to the expansion and contraction of the material; and, thirdly, by the decay of the material.

The following conditions should therefore be strictly adhered to in designing and constructing joinery:—

1st. Frame all parts in such manner as to allow for shrinkage or free expansion, at the same time making them of a thickness sufficient to prevent warping, this being best determined by experience.

2nd. In order to render the amount of shrinkage inappreciable, members should be made as narrow as possible.

3rd. All stuff should be thoroughly seasoned and chosen from the heart wood of a tree, all sapwood being rejected.

All the exposed surfaces are usually prepared to take a covering of paint or polish for decorative purposes, or to preserve it from the effects of the atmosphere. The wood employed is called stuff, and comprises battens from 2 to 7 inches in width and $\frac{3}{4}$ to 3 inches thick, boards 7 to 9 inches wide and 2 to $4\frac{1}{2}$ inches thick, and planks any width above.

The operations of joinery include sawing, planing, shooting, chamfering, rebating, grooving, scribing, moulding, mitreing, and the construction of joints and frames in such a manner as will allow the wood to shrink and swell without hindrance.

Sawing is the cutting of wood by means of saws. On machines these would be band or circular, but for hand use may be rip, hand, tenon, dovetail, key and fret saws.

Planing is taking shavings off wood by means of planes, and is described as dressed, wrought, which when brought to a level surface is said to be out of winding.

Shooting is planing the edges of boards straight and square with face.

Chamfering is taking the arris or edges off boards; forming a bevil, generally by means of a plane. When two chamfered edges are placed together, as in figure 385, it makes what is known as a V-joint.

Rebating.—The planing or cutting away of a rectangular section from the edge of the board.

Scribing is the fitting of boards to irregular surfaces, such as skirting to floors.

Plough Grooving.—Grooves made parallel to edges of boards, with a special tool called a plough.

Cross Grooving is the operation of forming a sinking across the grain, and is often done with a saw and router, as in the case of housings for risers and treads into strings, or a groove is sunk entirely across a board by a special plane with cutting teeth, called a grooving plane.

Tongues or Feathers are thin pieces of wood, usually pine veneer, cut $\frac{7}{8}$ inch wide, about $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, inserted in plough grooves, to prevent dust, light or air passing through the joint of battens or boards, should the latter shrink. If cut with the grain they are called straight tongues or feathers. Where cut across the grain, they are known as cross tongues or feathers. These are used where considerable shearing resistance is required, as the former under such conditions would split.

Moulding.—A piece of stuff is said to be moulded when it is worked on its face into a series of curves and bands; mouldings may be worked either by hand or machine. In the former case, they are struck by means of hollows and rounds, narrow planes, the cutting face of which are worked to segments of varying curves, or, if the moulding be small, to the reverse of the same.

The section is usually marked on the ends of the piece of stuff by means of a zinc templet cut to the section of the moulding. Where mouldings are produced on a large scale they are usually worked by machine.

Mitreing.—This is the process usually applied to the junction between two pieces of stuff that are jointed at an angle one with the other. If the two pieces to be joined are of an equal width, the mitre cut bisects the angle.

Scribing is the process of fitting linings or framing to an unequal surface, also of cutting one moulding to fit a similar moulding in an internal angle instead of mitreing.

Framing.—Large areas requiring to be covered with woodwork should comply with the conditions stated on page 171.

A frame is usually constructed by joining together narrow pieces of stuff, in width about 3″, with a mortise and tenon joint, as shown in figures 404 to 406. The pieces enclose a number of rectangular or other shaped spaces, and usually have grooves on their inside edges into which the edges of pieces of stuff termed panels are fitted. The framing completely encloses the panel, preventing it from twisting, but allowing it to expand and contract freely. The great bulk of the area should be taken up by the panels, only a relatively small portion being taken up by the framing.

The vertical members, forming part of the boundary of the frame, that are mortised are termed styles, all other vertical members between the styles are termed muntins, and the horizontal members are termed rails.

Method of Glueing up Framing.—When all the members have been prepared and fitted, the framing is laid upon bearers (the upper surfaces of which are fixed "out of winding"), and pulled up with an iron cramp, all the tenons and shoulders being coated with hot glue; it is then secured by wedges, dowel pins, or wedges and dowel pins combined, which have been dipped in hot glue. In frames for exterior work white lead is used instead of glue, and dowels are often employed, especially where mortises or slots are cut with a saw, as in figure 409.

Panelling and Moulding.—Specifications of framing named should include the method in which the panels are treated, and the manner and extent of the moulding of the frame.

The panels may be either flat, raised, raised and moulded, bead flush, bead and butt or flush only. The framing may be square or moulded.

There are three methods of moulding frames: first, by planting; secondly, by working the moulding on the frame; thirdly, by framing the mouldings, and grooving them into the frame.

Figure 367 shows a section of square framing and flat panel, and with a planted moulding. Figure 368 shows a section with the moulding stuck on the solid, and a raised panel. Figure 369 shows a framed bolection moulding with a bevelled raised and moulded panel. The object of bevelling is to add strength to the panel by having the latter of greater thickness than the circumscribing groove. Care must be taken to make the thickness of the panel that enters the framed bolection moulding parallel, otherwise, if any shrinkage takes place, the panel becomes loose if the bevelling be continued to the edge of the panel. In order to gain strength the panels are often made flush with the framing, as shown in figures 370 and 371.

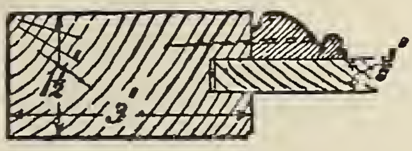


Fig. 367.

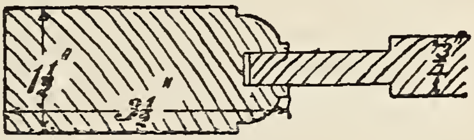


Fig. 368.

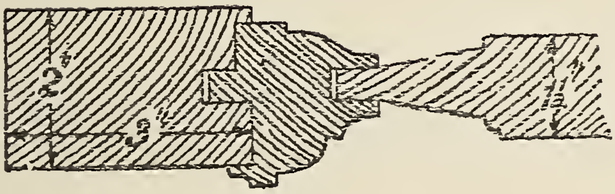


Fig. 369.

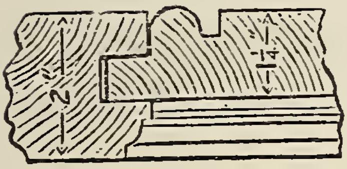


Fig. 370.

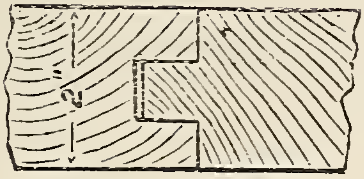


Fig. 371.

The method of planting mouldings is bad, and should never be used for good work; but where adopted, care should be taken that the mouldings are nailed to the frame and not the panel.

Small mouldings are best stuck on the solid. These mouldings should be scribed together at the angles where the section and position render it possible, otherwise they are mitred.

Mouldings exceeding 1 inch in width should be framed. The framed mouldings are usually mitred, tongued, glued and screwed at angles.

Mouldings are often continued from the sides of a frame, and planted on the face of the panels to various designs under these conditions.

Great care must be taken to fix the mouldings so that the grain of the moulding is in the same direction as the grain of the panels; this will necessitate a large amount of the moulding stuck across the grain. If this be not done, those mouldings that are fixed with their grain at right angles to that of the panel will after a short time become detached, owing to their inability to expand or contract with the panel; they also have the tendency to split the panel.

Flush Panels.—Panels are often prepared flush with the framing on one or both sides in order to obtain increased strength. A bead is usually stuck on the edges of the flush side that are in the direction of the grain to save the appearance of the large open joint that occurs when the panel shrinks; the transverse edges are left square, as the panel does not shrink in the direction of its length. Such panels are termed bead butt. Flush panels of the above description often have the bead carried round the four edges of the panel; this is bad as carried out in ordinary practice, the transverse bead being let into the panel, and having its grain at right angles to same, thus preventing its shrinking freely, the panel being frequently split. If beads are required on the four sides, they should be stuck on the frame. Panels are often made flush both sides, being ornamented with beads or mouldings on both sides, or left plain; the latter usually being done where it is required to cover the same with baize or other material.

Mouldings.—Most of the groups of mouldings used by the joiner consist of combinations of some of the Greek or of the eight Roman examples. Invariably the Roman mouldings are found to have their prototype in the Grecian examples, the chief difference being that the Greek are either segments of some of the conic curves or are struck freehand, while the Roman curves are all segments of circles.

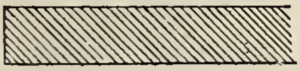


Fig. 372.

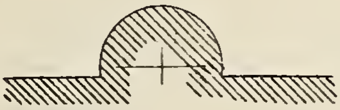


Fig. 373.

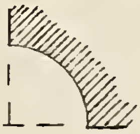


Fig. 374.

(1.) *Fillet.*—This is a narrow flat projection often used to divide individual or groups of mouldings in any composition; it is similar in both Greek and Roman work, as shown in figure 372.

(2.) *Astragal* is a small semicircular moulding, as shown in figure 373, often used in combinations of mouldings, but chiefly to mark the division between the shafts and caps of columns. It is also largely used in the joints of straight members in joinery that are not glued, such as the joints of matchboarding or the meeting styles of doors, sashes, etc., so that if the wood shrinks the shadow cast by the moulding will detract from the unsightliness of the joint. This member is similar in Greek and Roman.

(3.) *Cavetto.*—The cavetto is a hollow moulding, as shown in figure 374, consisting in the Greek of a quarter of an ellipse and in the Roman of a quadrant.

(4.) *Ovolo.*—This moulding in the Greek consists of a segment of an inclined ellipse, having a fillet at the top and bottom, and forming at the top a quirk. In Roman work, as shown in figure 375, it is a quarter circle, rounded at top and bottom by a fillet.

(5.) *Cyma Recta.*—This is a double curve, formed in the Greek of two quarter ellipses whose minor axes are in the same straight line and bounded top and bottom by a fillet. The Roman example, as shown in figure 376, is similar, but consisting of two quarter circles. This moulding has a concave portion of its surface above the convex, and is generally used as a crowning member.

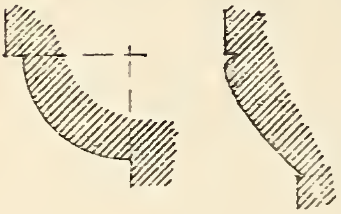


Fig. 375.

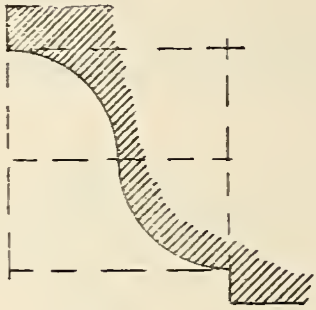


Fig. 376.

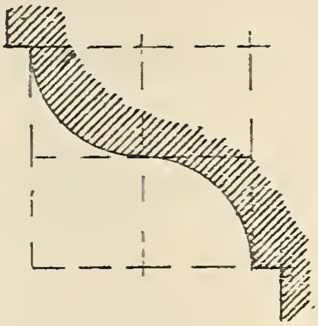


Fig. 377.

(6.) *Cyma Reversa*, as its name implies, is the reverse of the preceding moulding, slightly modified in the Greek by having a quirk above, between the same and the fillet, and the hollow portion slightly more concave. The Roman is an exact reverse, as shown in figure 377.

(7.) *Scotia.*—The scotia in the case of the Greek is formed of an inclined ellipse, having a fillet above and below. The Roman is struck from two centres on a common radial line, as shown in figure 378.

(8.) *Torus.*—The torus is a base moulding, the Greek form being the reverse of the scotia. Many Greek examples are, however, similar to the Roman, consisting simply of a large semicircle with a quirk below and a fillet above, as shown in figure 379.

(9.) *Birds Beak.*—This moulding only occurs in the Greek mouldings; it consists of a quarter ellipse (with the major axis horizontal), in the lower side of which a small hollow has been worked, as shown in figure 380.

In the designing of groups of mouldings for cornices, strings, etc., reference should be made as to the suitability of the mouldings for their intended position, and for this purpose they may be divided into base mouldings, supporting mouldings, and crowning mouldings. The base mouldings would include such mouldings as the inverted cavetto, the torus, the scotia or the inverted cyma recta, and any combination of such mouldings that would tend to broaden the base and distribute the weight of the mass supported.

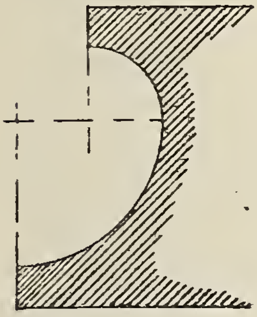


Fig. 378.

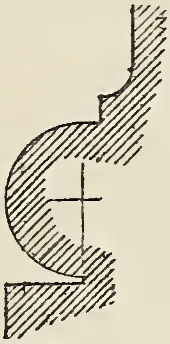


Fig. 379.

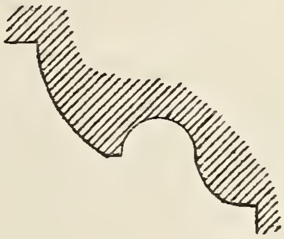


Fig. 380.

Supporting.—The supporting mouldings include such members as the ovolo and the cyma reversa, mouldings that do not have their hollow members near their upper edge, and such as have their mass in a position to strengthen the same, and are fitted to act as corbels. These mouldings are used to form the bed mouldings or lower parts of combinations, such as cornices which are divided into two parts, the bed mouldings and the crowning mouldings.

Crowning Mouldings are those mouldings which are not expected to carry anything above, such as the cyma recta and the cavetto, the top members of which are small and delicate.

The above ideas are not always rigidly adhered to, and successful departures from the same are often made with good effect; but it is prudent to bear these principles in mind when designing any groups, as if too widely departed from confusion ensues.

Joints.—Joints in joinery are classified as follows:—1. Side joints; 2. Angle joints; 3. Cross joints; 4. Joints to prevent warping, and framing joints.

(1.) *Side Joints.*—The side joints that have been used in connection with floors have been explained and illustrated in the chapter on that subject. The remainder are as follows:—The plain or square joint: in this case the edges are shot true, so that if a straight-edge be applied to their common face when the boards are applied one to the other, it shall be in an approximate plane: it is necessary to try the boards in this way, and not attempt to shoot the edges square, as the boards generally cast and twist a certain amount in their rough state. When the joint is prepared the two edges are applied together and are glued; this accomplished, the edges are placed in position and the top board rubbed backward and forward on the bottom to rub all the superfluous glue out of the same and to cause a certain amount of suction. When the joint is adjusted it is left till it is dry, and then cleaned off and prepared for the purpose for which it is intended.

While the joint is in a wet condition the pieces are often secured by cramps or cleats, to prevent any movement in same till dry. All kinds of glued joints between boards should be treated in this way. Figure 381 shows a plain joint.

(2.) *The Tongued Joint.*—In this method, as shown in figure 382, the edges are shot as before, a groove is made in the centre of each of same $\frac{1}{8}$ by $\frac{1}{2}''$ in depth at the most by means of a plough. Cross tongues 1″ in width are then inserted in one of the grooves, the joint is then tried, glued, and rubbed as before. Increased strength is obtained in the joint by this method, as a larger glued surface is obtained and the two pieces are to a certain extent interwoven. It is not good, however, for panels of ½″ or under.

(3.) *The Dowelled Joint.*—The edges in this joint are shot in the ordinary manner, the boards are then placed face to face with the shot edges uppermost, they are squared across about every 18″, a gauge mark is scratched about the centre of the edges from the face of each board (thus obtaining the exact centre for each dowel), the holes are then bored about ¾″ deep, the dowel inserted, the edges glued, and the boards cramped up. This makes a very strong joint, as shown in figure 383.

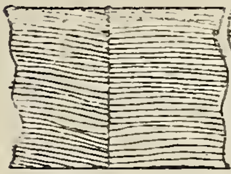


Fig. 381.

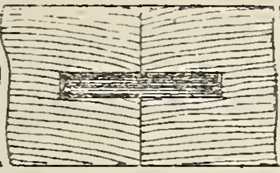


Fig. 382.

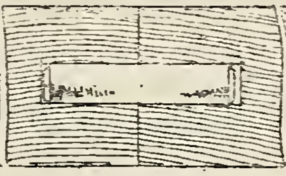


Fig. 383.

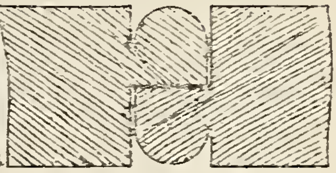


Fig. 386.

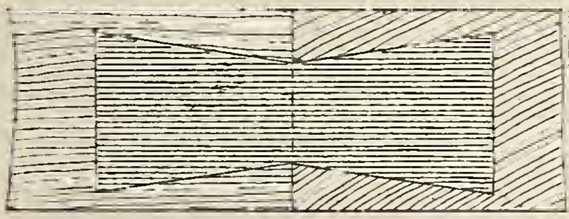


Fig. 384.

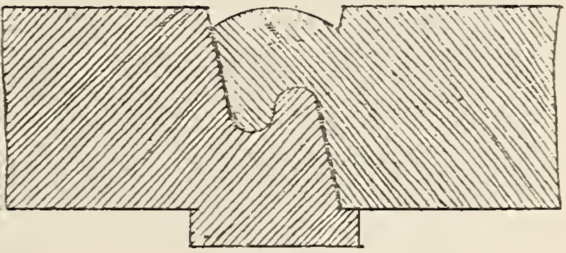


Fig. 387.

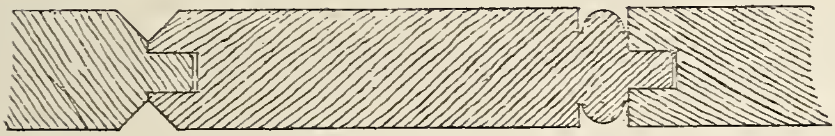


Fig. 385.

Keyed Joint.—This joint, as shown in figure 384, is not much used at the present except in imitation of old work. It consists of a dovetailed shaped key, about 3″ in length, let into the ends and the back of the boards to be joined, and cleaned off level with the back of the same.

There are several side joints in which the pieces are not intended to be glued together such as the following:—

(1st.) *The Matched Joint.*—The form of the joint, as shown in figure 385, is a grooved and tongued arrangement, having on the tongued edge a moulding, generally a chamfer or a bead, to emphasise the joint, and so obliterate the ill effects of the open joints that ensue on shrinkage. Matchboards are employed in the place of framing where large surfaces are to be covered. They should not be more than 4″ in width and should be nailed on one edge only, in order that no joint shall open too much and that the whole shall be free to shrink. A similar joint to this is used for the joint of horizontal sliding sashes where it is desired to obtain a dust and draught proof joint.

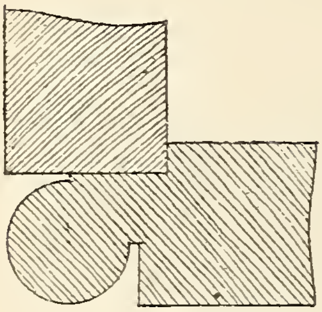


Fig. 388.

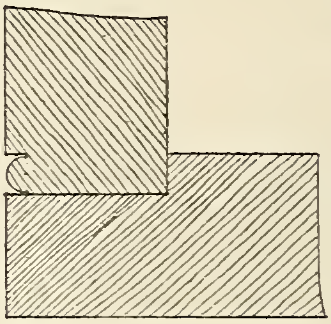


Fig. 389.

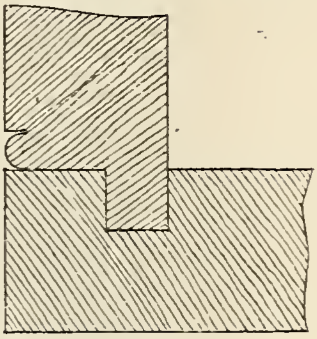


Fig. 390.

The Rebated Joint.—This is generally employed for the meeting styles of folding doors and sashes for the mutual support of each other, and to prevent an unobstructed through joint, see figure 386.

The Hook Joint.—This is used in the meeting styles of casement sashes to form a draught and water proof joint, as shown in figure 387.

Angle Joints.—These joints are divided into three classes. 1st. Those in which the joint is parallel to the grain of the pieces joined. 2nd. Those in which the joint is at right angles to the pieces joined. 3rd. Those which may be used in both of the above cases.

1st Rebate, Butt, and Staff Bead.—In this, as shown in figure 388, there is a rebate formed, so that the pieces may be easily placed in position, a staff bead being worked at the angle to ornament same. The two pieces are secured by nailing, or by glueing and blocking.

Rebate Butt and Bead.—This is worked similarly to the preceding example, having a small bead at the side instead of a large angle bead; it is used where one face is required perfectly plain. This is shown in figure 389.

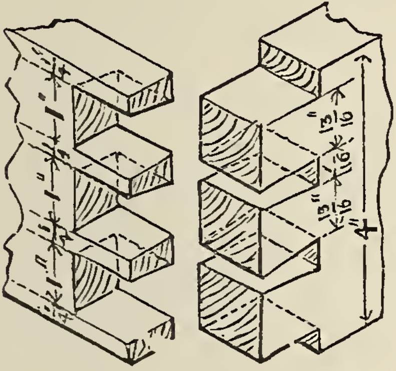


Fig. 391.

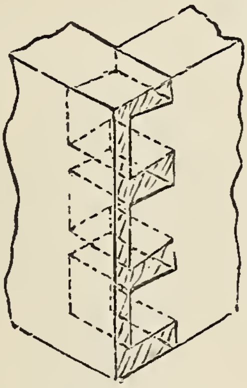


Fig. 392.

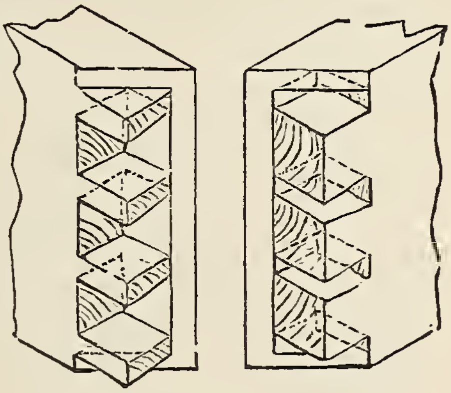


Fig. 393.

Groove Tongue and Bead.—This member has a tongue instead of a rebate, as shown in figure 390. These three forms are usually employed where the work is fixed piece by piece, it being difficult to obtain a close joint; the moulding is added to counteract this defect. If the angle is glued, some form of a mitred joint is generally employed.

Joints across the Grain.—The principal joints for this purpose are, 1, the common dovetail; 2, the lap dovetail; 3, the secret dovetail, the first being used if the visible joint be of no account, the second where it is desirable to have one face perfectly clear, and the third if both faces are to be seen. They are made as shown in figures 391 to 393.

The Keyed Mitre.—The pieces are here mitred, placed into position, and a number of pairs of saw cuts inclined to each other made across the angle. The joint is then glued, put together, and into the cuts are fitted coarse shavings, which are glued and fit tightly, as shown in figure 394.

Joint common to both directions of Grain.—These resolve themselves into some form of the mitre joint; the common mitre, as shown in figure 395, is easily formed but difficult to fix together, and is unreliable unless glued and blocked for its whole length.

The Mitre and Tongue is a good and strong form, but the grooves are difficult to form unless a machine is used.

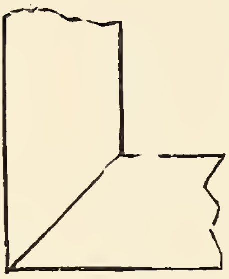


Fig. 395.

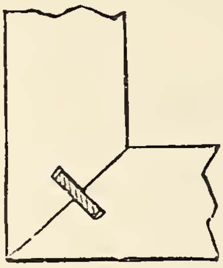


Fig. 395A.

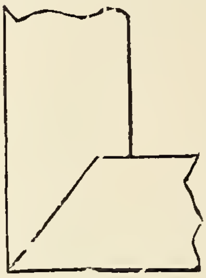


Fig. 396.

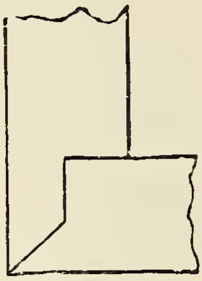


Fig. 397.

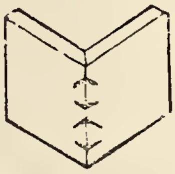


Fig. 394.

The Mitre and Butt, as shown in figure 396, is a form used where the pieces are of unequal thickness.

The Mitre and Rebate, as shown in figure 397, is a little more difficult to form, but is a very good form for jointing, especially where nails only are employed.

Mitre, Rebate, Butt and Tongue.—This form is used where the joint is parallel to the pieces joined; it is used in the best work, for the angles of pilasters, etc. It is glued and blocked, if possible no nails being used.

Cross Joints.—Cross joints are of two forms. 1st, those in which the edges of one piece is fitted into the side of the other; 2nd, those in which the pieces completely cross.

1st. *The Housed Joint*, as shown in figure 398, is used where the pieces are gauged to a thickness, and it is possible easily to fit the one exactly into the other, the two pieces being secured by nailing.

2nd. *The Shoulder and Housed.*—This is used either where the housed member is rough on one side, a tongue is therefore worked as being the most expeditious method of fitting, or where the internal angle is to be seen. In this case the shouldered joint gives the cleaner appearance. This joint is shown in figure 399.

3rd. *The Dovetailed Housing.*—This is employed where it would be undesirable to fix the pieces by nailing, and is shown in figure 400.

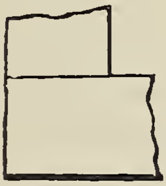


Fig. 397A.

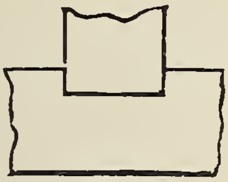


Fig. 398.

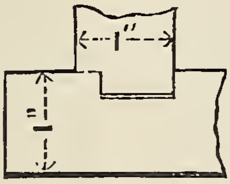


Fig. 399.

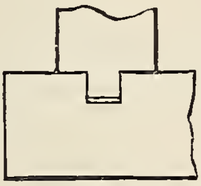


Fig. 399A.

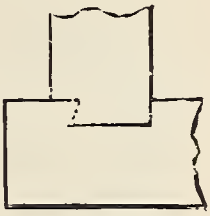


Fig. 400.

The second class of cross joints are used in constructing the carcases for drawers, or for nests of shelves, etc.

In the first instance the uprights are usually solid, and the horizontal rails are about 3″ wide. The joint is a combination of the halved and housed joint; the idea is to have both members continuous and so increase the tie. The same arrangement is used for positions in which the members are of an equal width.

Joints to Prevent Warping in Wide Surfaces.—All boards have a tendency to warp or cast if left to themselves or with insufficient fixing, and when several are jointed for such purposes as table-tops, facias, dados, or sign-boards the defect is liable to be greater. To reduce the amount of the casting to a minimum, the boards should be selected and matched with the heart side of adjacent boards on opposite faces of the work, and means must be taken to fix the boards in a flat position, but in a manner that they will be able to shrink and expand freely. There are four general methods employed for this:—1, the dovetailed key; 2, the batten and slot screw; 3, the batten and button; 4, by iron rods.

In the first method, as shown in figure 401, a wood key of the shape shown in figure, dovetailed on its edges, is fitted to a cross groove made to receive the same. The object of tapering the key is to render it easier to fit. After the key is driven in, it is screwed at its widest end.

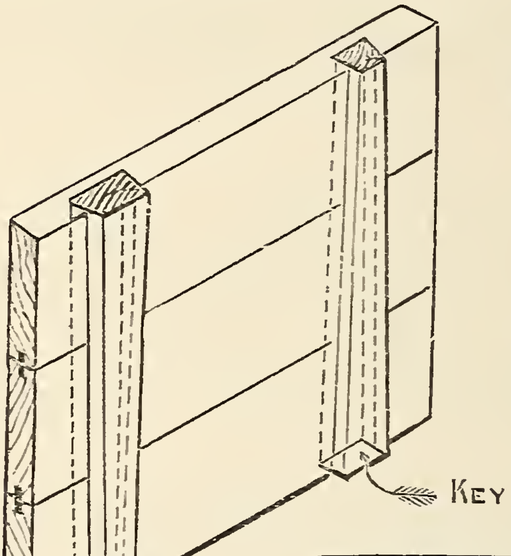


Fig. 401.

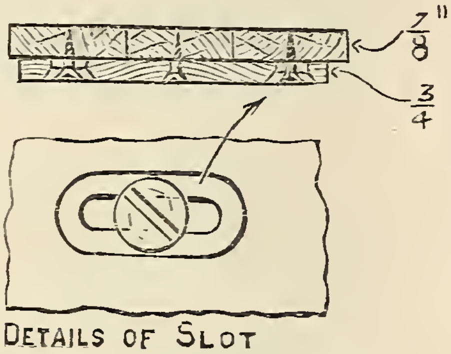


Fig. 402.

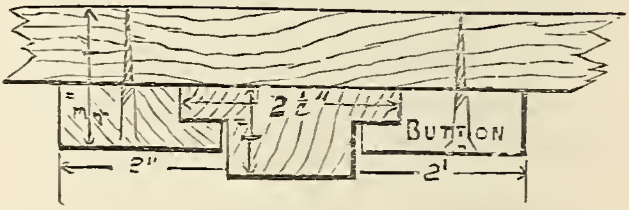


Fig. 403.

The Slot Screw and Batten.—By this method a batten of sufficient thickness is prepared with a number of countersunk slots in same, into which are let brass slots; these are placed on the back of the work, one screw is driven in the ordinary way through the centre of the batten to fix the same, screws being driven into the centre of each slot; the latter fix the batten and board together, but allowing the latter freedom to expand or contract, see figure 402.

The Batten and Button.—This method is more effective than the last, but is unsightly. It consists of a rebated batten screwed to board in centre and secured by hardwood buttons of the form shown in figure 403.

The Iron Bar.—In this case a hole is bored through the edge of the boards before they are glued up. The iron bar is next passed through the hole in the edges, which latter are glued, and the joints are closed by means of cramps. This method is very effectual, especially if both sides of the work are exposed to view, or where there is no room for any projections at back.

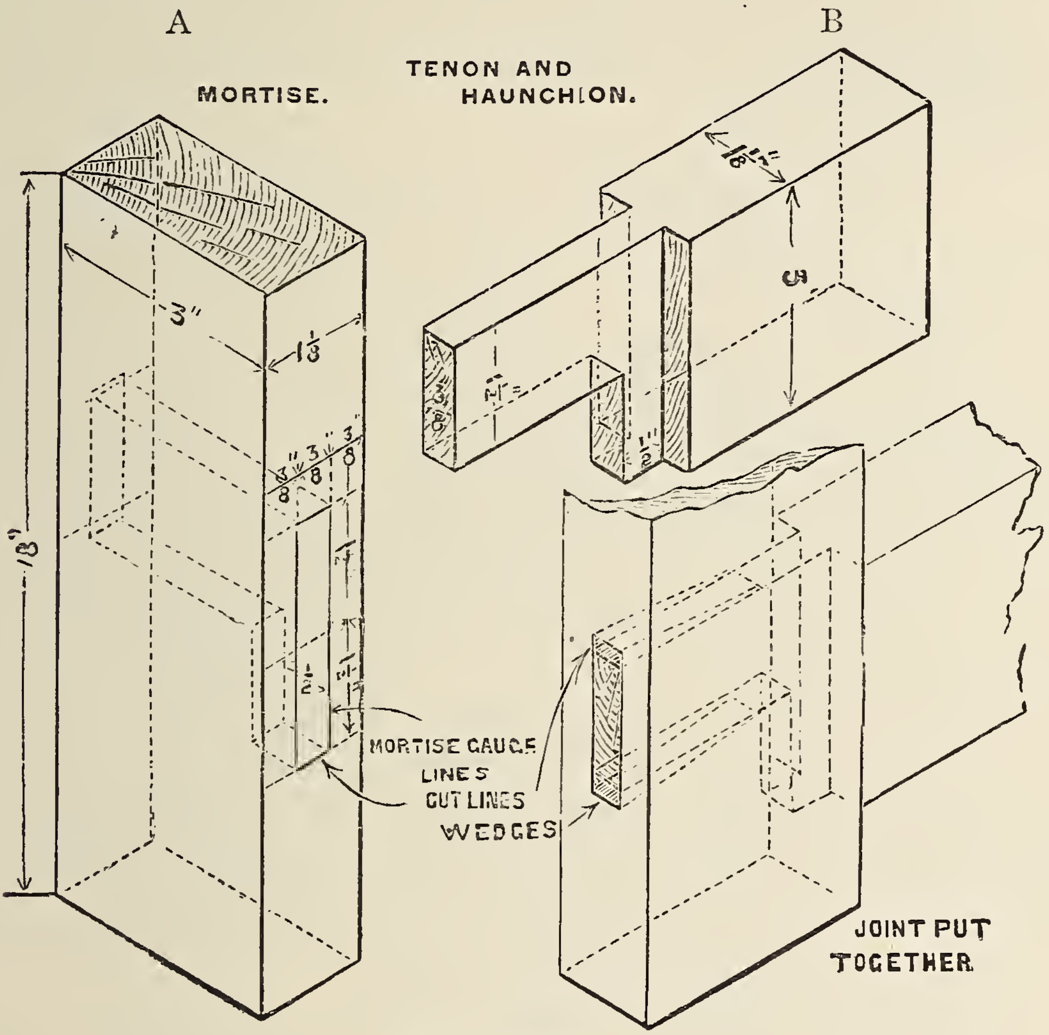


Fig. 404.

Framed Joints.—These joints invariably resolve themselves into some form of the mortise and tenon joint.

The form of the mortise and tenon joint is shown in figure 404. The typical dimensions for such a joint are as follows :—The thickness of tenon should be $\frac{1}{3}$rd of the thickness of the stuff and the width should not exceed four times the thickness, and in no case more than 2″ in width. The reason for the latter rule is that if the tenon is of a greater width than that stated, it has a tendency to bend under the pressure of the wedges, and in the second place it is necessary to keep the tenon sufficiently narrow to render the shrinkage in same inappreciable.

Haunchion — Consists of a stump tenon, usually $\frac{1}{2}$ inch long, adjoining the tenon proper, fitting into a groove cut to receive it, as in figure 404, to prevent the tenoned piece twisting, also to obviate a through joint and to keep the surfaces of the rails and styles in the same plane should the joint shrink or become loose. The shortness of the haunchion adds great strength to the root of the tenon, about which, but for the haunchion, it would often snap when exposed to sudden shocks. The roots of tenons in thick stuff are sometimes also assisted to resist stress by cross tongues, as in figure 404A.

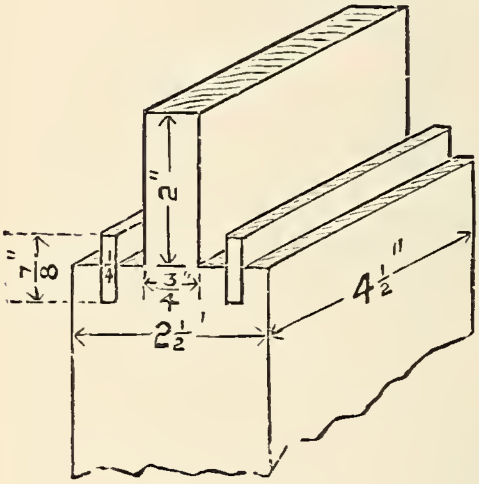


Fig. 404A.

The wedges employed should be thick at the narrow end and have a very slight inclination, in order that when they are driven home they shall compress the tenon with the greatest force at the root, so that should any shrinkage take place in the style, its direction would be towards the shoulder.

Double Tenon.—Figure 405 shows a double tenon, which is used if the framing is very thick, or as in this case where it is intended to fix a mortise lock into the style; the minimum distance between the tenons should be the thickness of the lock. The rule respecting the thickness of tenons is here departed from for want of room, but for other parts of a door or framing it would be observed.

Joint at Lock Rail of Diminished Style.—This joint is similar in principle to the ordinary lock rail, the difference being that it is moulded at the top and has a bevelled joint.

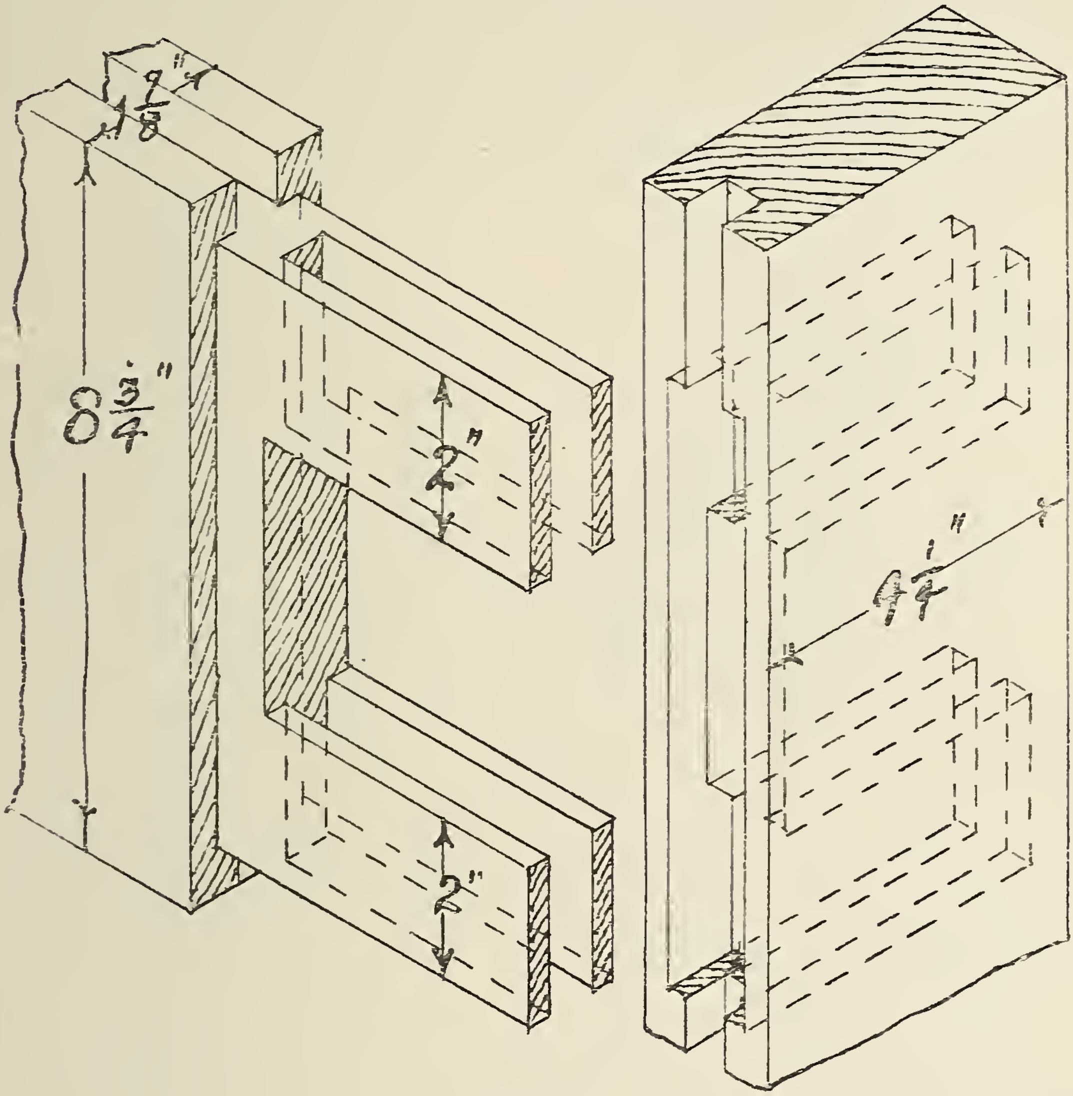


Fig. 405.

Bottom Rail.—Where the bottom rail is wide there are two tenons which are placed differently from the middle rail, owing to the end of style and bottom edge of rail being flush.

Foxtail Wedging.—Figure 406 illustrates the method of fixing known as foxtail wedging. The mortise in this case is stopped about ½" from the back edge of style, and is cut slightly dovetail in shape. The tenon has a saw cut about $\frac{1}{8}''$ from each side, into which a wedge is inserted, and on being cramped up the wedges are forced home. There should be a space allowed in the mortise at the end of the tenon of the thickness of the wedge, otherwise in the event of a wedge being turned over, it would prevent the joint closing, and it would be a matter of great difficulty to withdraw the same. This joint is employed in the best work, where it is undesirable to see the end grain of the tenons penetrating the styles.

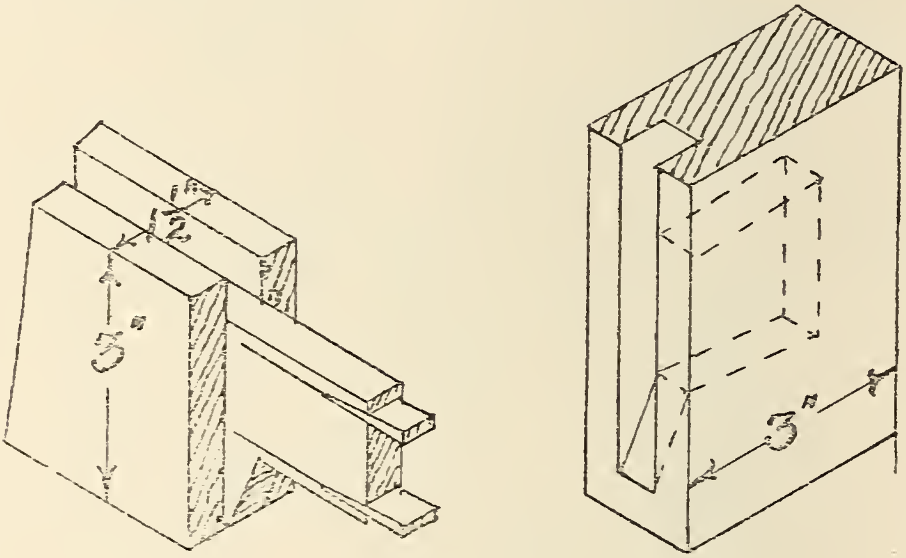


Fig. 406.

The joints at the angles of moulded sashes are similar in principle to the above, but modified, as shown in figure 407, to meet the different conditions.

Joints employed in Double Hung Sash Frame.—Figure 408 indicates the method of constructing the joint between the side and sill, and the side and head of the above-mentioned frame. The sill and head are housed as indicated. The pulley lining is wedged and nailed to sill. The head is nailed to pulley lining only; the end of head is slotted to receive parting slip. The frame in this condition is squared, and the linings are nailed on to each side of the frame. The back linings are fixed and the head linings are blocked, and when the beads are in the frame is complete.

Solid Frames are used for doors and window openings, and consist of posts, heads and sills, and are sometimes divided by horizontal members called transoms, and vertical pieces known as mullions. The posts and heads are generally bedded against plaster screeds, worked against brickwork, to prevent wind and rain from entering at those joints, and to reduce the vibration caused by opening and closing doors and windows. The joints occurring between frames and stonework are usually pointed only.

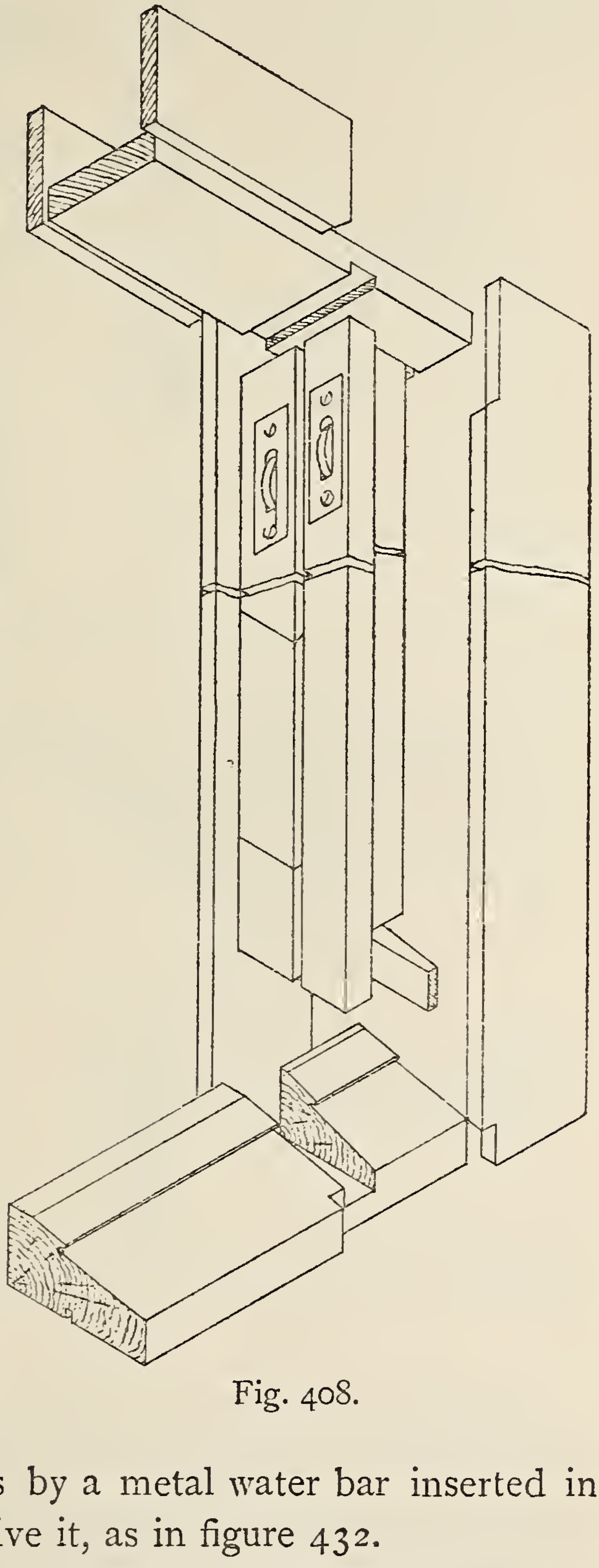


Fig. 408.

Solid Window Frames.—These are used for fixed sashes, casement sashes, and sashes hung on centres. These frames always include head, posts, and sills (except in the circular form); the heads and sills are usually cut between the brickwork or masonry, and fixed by folding wedges, as shown in figure 426. Water is prevented from passing through stone and oak sills by a metal water bar inserted in plough grooves sunk to receive it, as in figure 432.

The joints at head are tenoned, the post mouldings are scribed to the head. In the transom joint the mouldings on the post are scribed, the transom having a square shoulder. The mouldings on post are also scribed to sill. These frames should be double tenoned when above 4½ in width (as in figure 435), to exert a greater pressure on the shoulders.

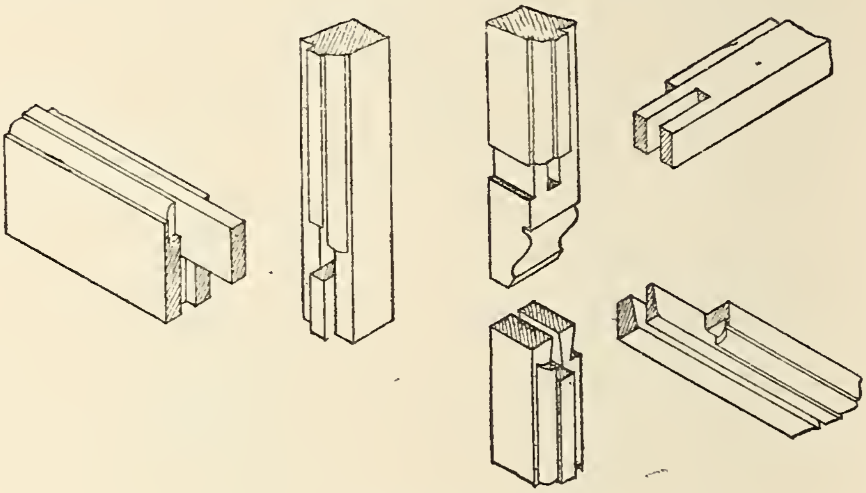


Fig. 407.

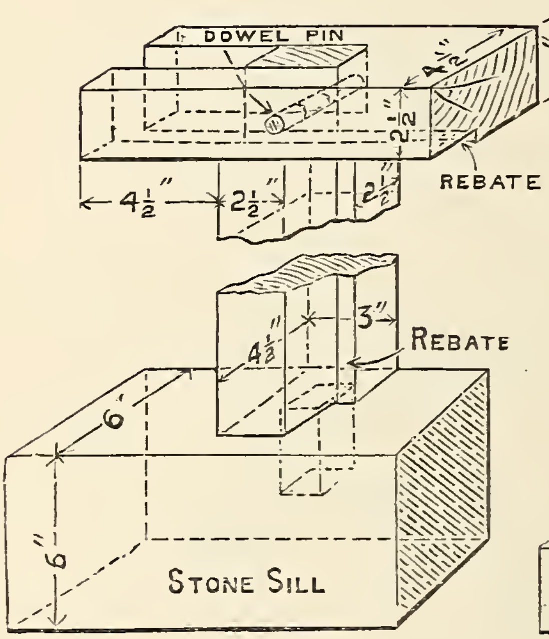


Fig. 409.

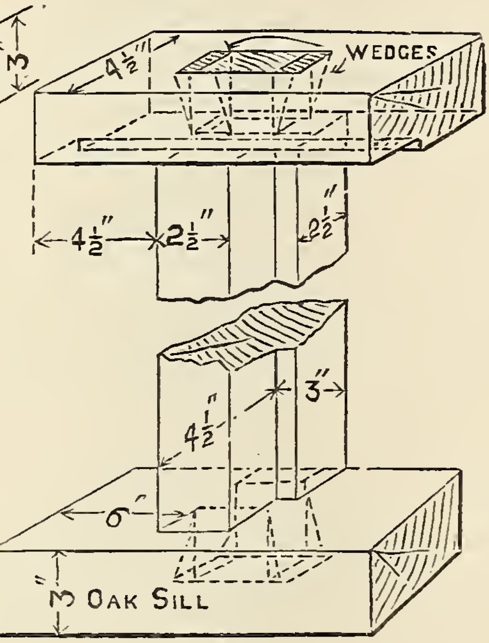


Fig. 410.

Solid Door Frames consist generally of two posts tenoned to head, which may be left projecting about 4½ inches, and built into wall. The joint at head of door frame is similar to that at head of casement frame. The feet of posts may be joggled to stone sills, as in figure 409. Sometimes instead of a joggle an iron dowel, about 3 inches long and 1 inch square, is used; better still, cast-iron shoes, about $\frac{3}{8}$ inch thick and 4 inches deep, with a joggle are made to enclose the feet. The shoes are sunk flush in the sides of the posts and the joggle in the sill.

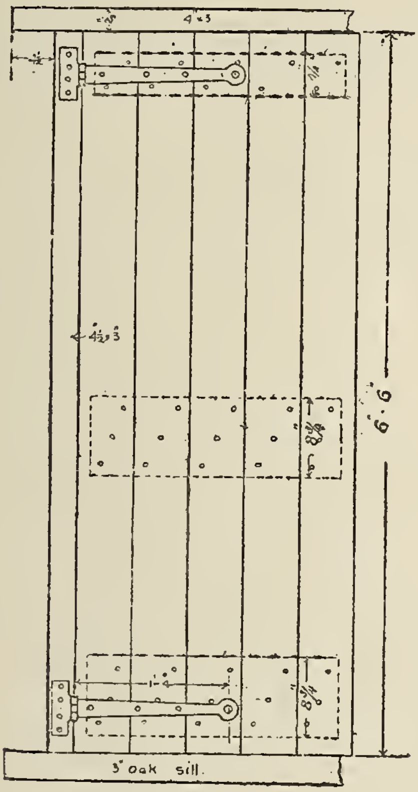


Fig. 411.

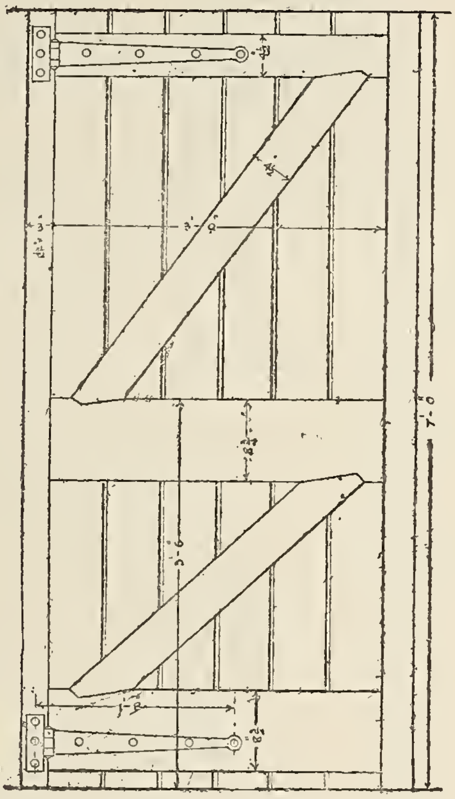


Fig. 412.

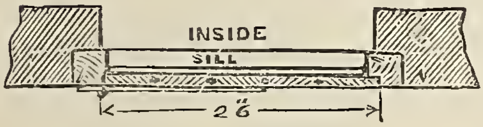


Fig. 413.

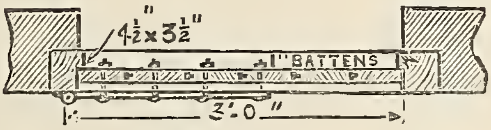


Fig. 414.

Doors.—These may be divided as ledged, ledged and braced, framed and braced, and framed and panelled doors.

Ledge Doors consist of a number of vertical battens, fixed by wrought-iron nails, driven in from the face of battens, and clenched to horizontal rails or ledges. This is the commonest description of door, and is used for temporary purposes, outhouses, etc. The battens may be square, ploughed and tongued, grooved and tongued, or chamfered, and are generally fixed to posts by cross garnets or strap hinges with screws.

Ledged and Braced—Are doors made in a similar manner

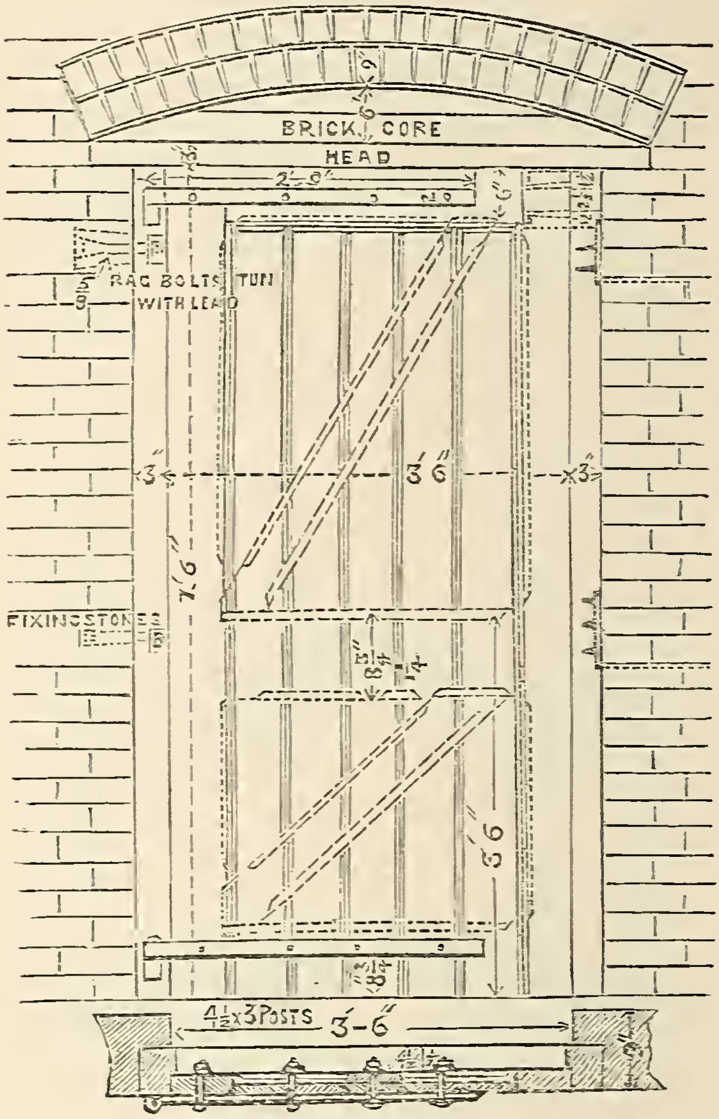
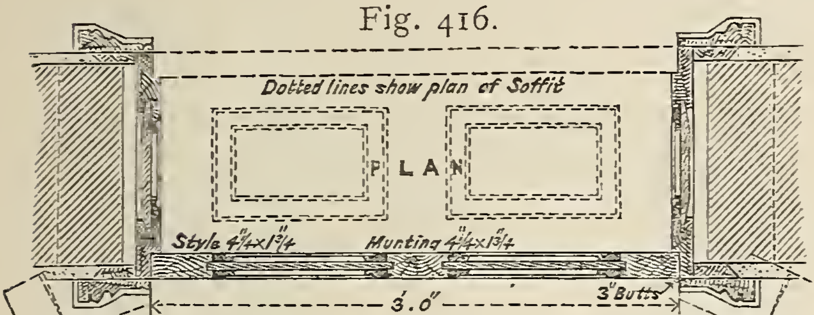


Fig. 415.

to the ledged doors, but having in addition braces, which stiffen the doors and keep the same from dropping at their free edge; the lower end of braces should always be near the supported edge. The joint with a brace and rail is generally made as in figure 412, which shows the battens grooved, tongued, and beaded, and hung by cross garnet hinges.

4-Panel Internal Door and Finishings.

Fig. 416.



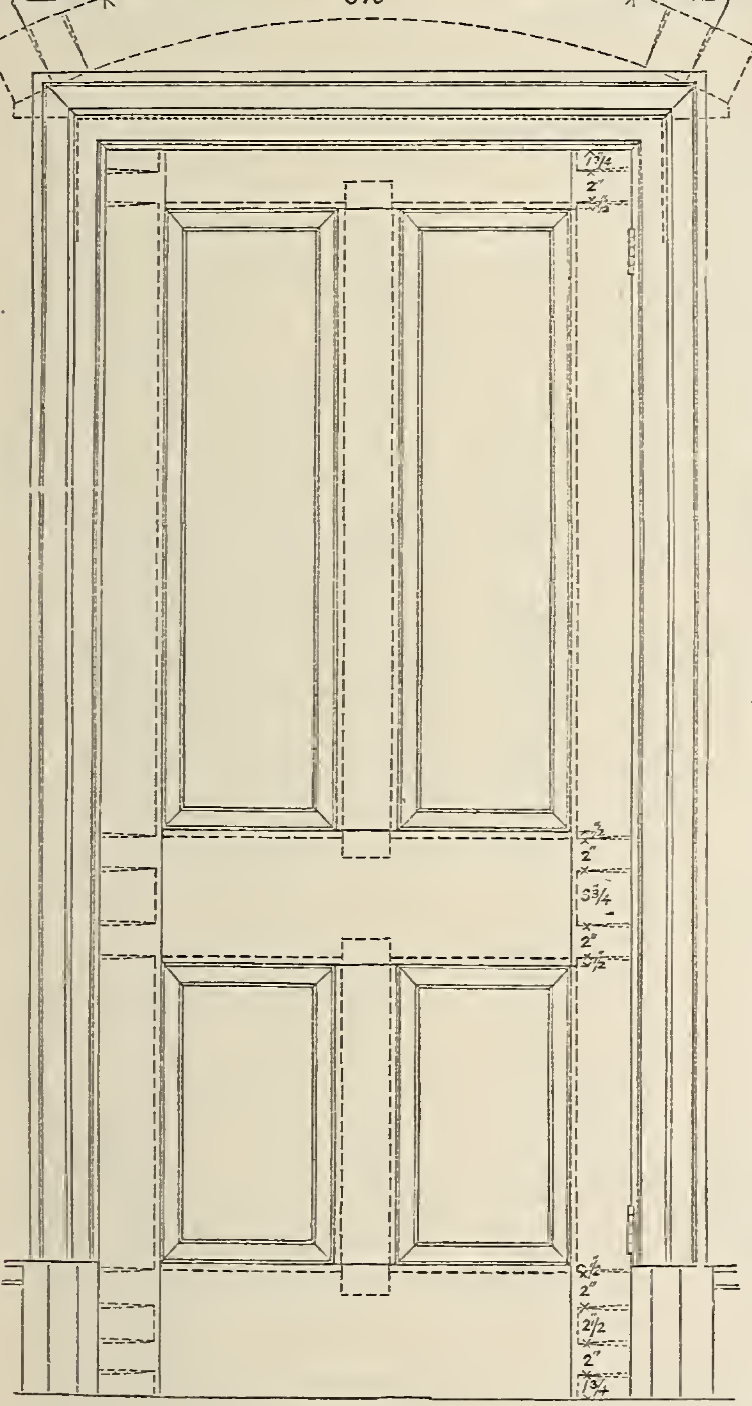


Fig. 417.—Elevation.

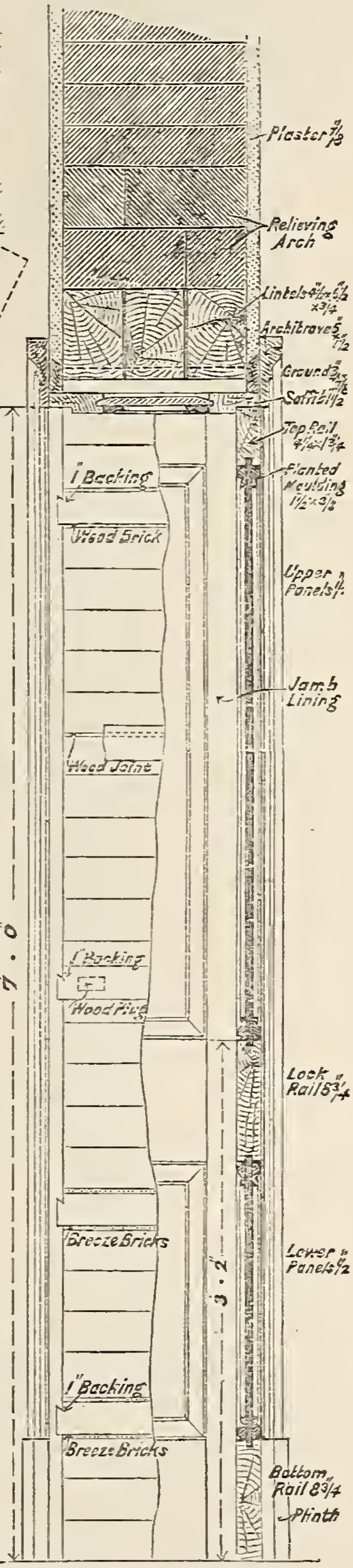


Fig. 418.—Section.

Framed and Braced Doors.—These are a good and strong form of door, and extensively used for external work to withstand rough wear. A framing is made, styles and top rail being of equal thickness, bottom and middle rails with the braces having a thickness equal to the styles, minus the thickness of battens, all members flush on the back. The bottom and middle rails are cut with barefaced tenons, and the braces may be stub-tenoned into rails and styles, as in figure 415. The battens are then pushed into their position, and secured to rails and braces by wrought-iron nails

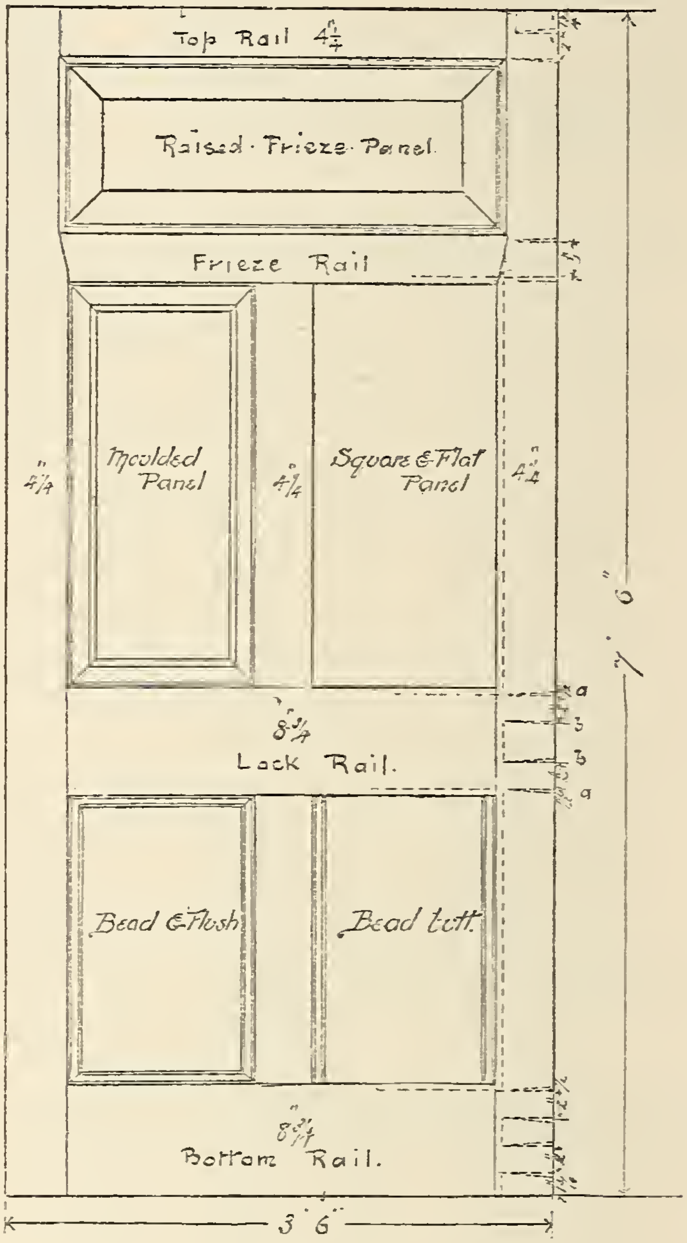


Fig. 419.

hammered in from the face and clenched at the back. The battens extend from top rail to the ground, more effectively to let any water drain off the door that might fall upon it. Hook and eye hinges are suitable for hanging these doors.

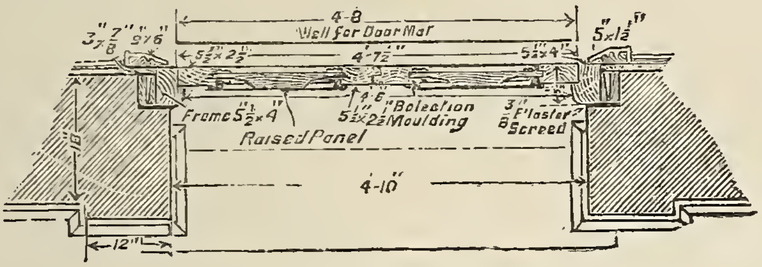


Fig. 420.

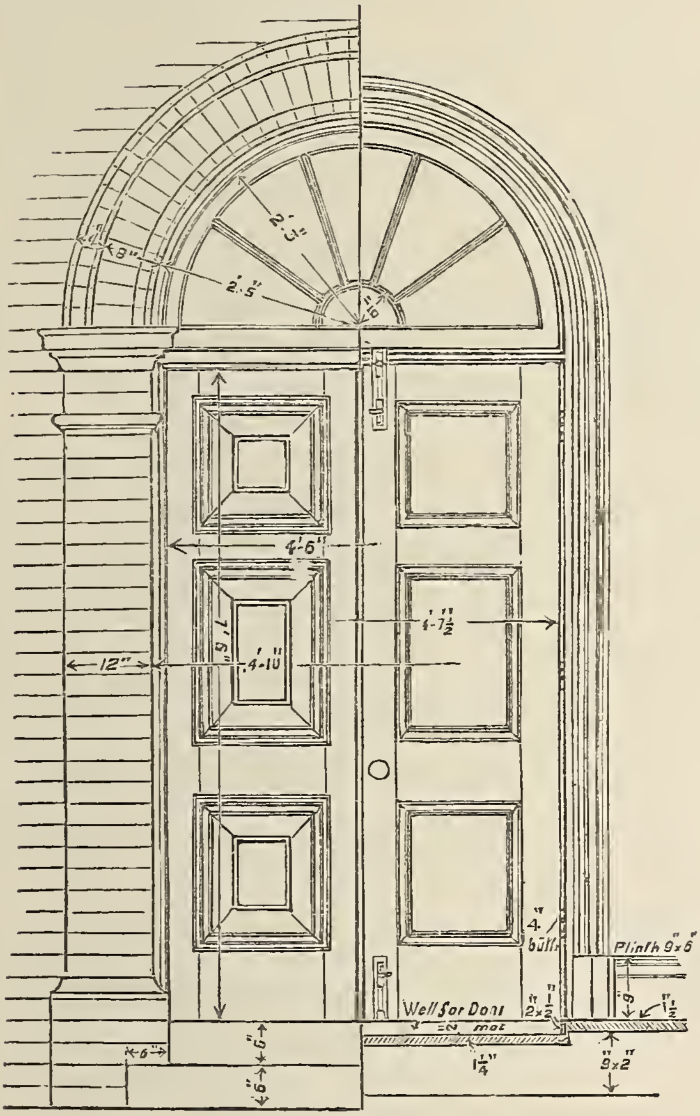


Fig. 421.

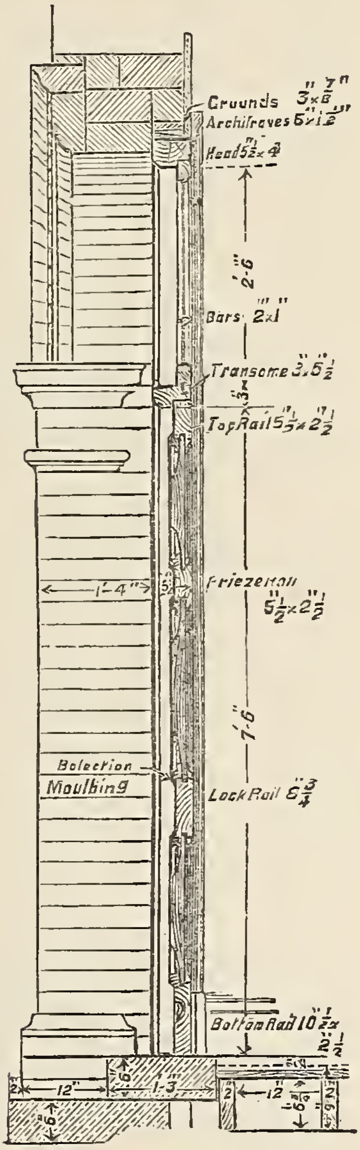
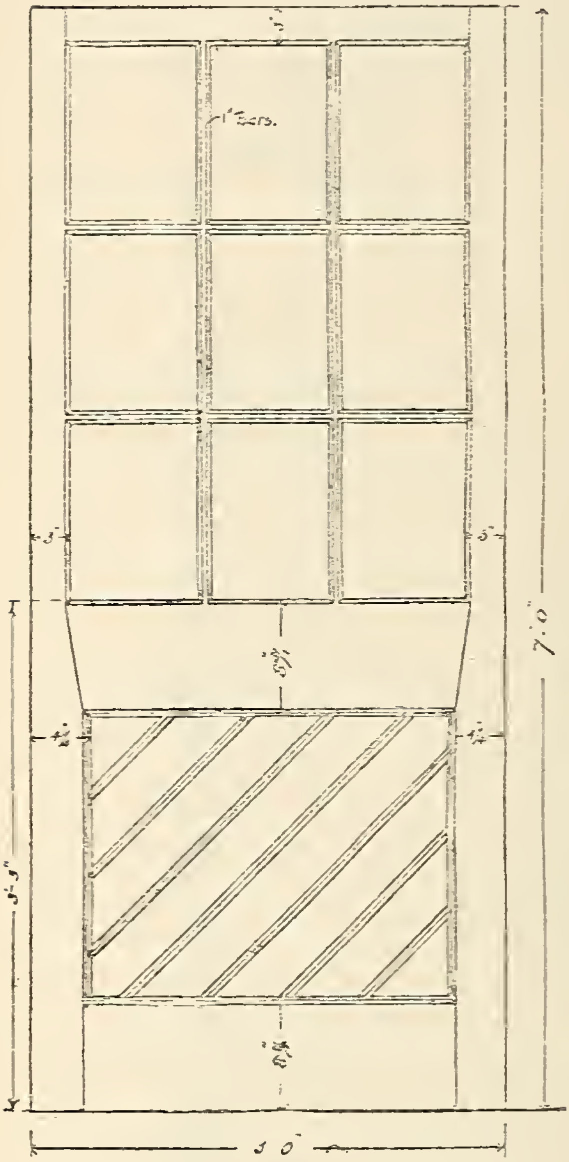


Fig. 422.

Framed and Panelled Doors.—These are described by the number of panels they contain, and consist of styles, rails, muntins and panels.

Fig. 423.



Four-panel Doors.—Figure 417 shows a four-panel door 7 feet high, 3 feet wide, and finishings for same, with all the necessary dimensions. The height of the top line of middle or lock rail is usually between 3 feet 2 inches and 3 feet 6 inches, so that the handle of door coming in the centre of lock rail may be a convenient height. Doors are usually hung on butts, as in figures 417 and 421.

Five-panel Doors.—Doors 7 feet high and over that height are often divided into more than four panels, and the rail, between top and lock rails, is called a frieze rail, and the top panel a frieze panel, as in figure 419.

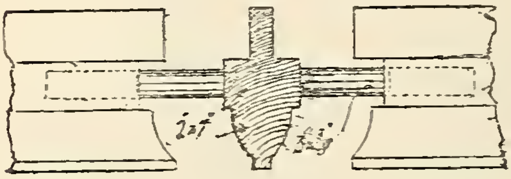


Fig. 424.

Folding Doors.—A pair of doors hanging one on each door jamb or post is described as folding doors, as in entrance doors, as shown in figures 420 to 422.

Sash Doors are doors the upper part of which are arranged for glass panel or panels, the styles of which are sometimes narrower at their upper part to gain more light, and are called diminished styles, as in figure 423.

Chamfered Panels are panels made of narrow battens, chamfered on edge, and together forming a V-joint, as in figure 385. The battens are sometimes cut and arranged diagonally, as in figure 423.

Saddle-back Board.—In order to allow doors to easily clear carpets without having a wide joint at bottom when closed, a saddle-back board is fixed, as shown in figure 425, which allows a wide joint when door is open.

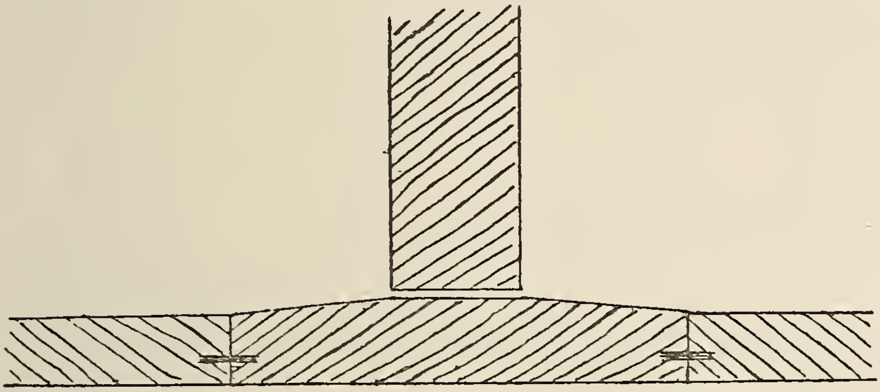


Fig. 425.

Sashes are frames formed of styles, rails, and bars, which are rebated to receive glass panels, and the wood members may be plain, chamfered or moulded. The rails are tenoned to the styles, and ends of bars may be tenoned to styles, rails or bars, or where intersecting another bar may be scribed and dowelled, as shown in figure 424, or scribed and tenoned. The through bars of sashes if they be rectangular should be across the narrowest width, or in the direction of the impact or stress. In double hung sashes and those hung on centres the through bars would be vertical, in casement sashes would be horizontal.

Sashes hung on Centres.—For factories, stables, lantern lights, and other positions where economy is an object, or in positions that would be inconvenient to be hung with weights on cords, sashes hung on centres in solid frames are employed, and are especially suitable to obtain light and air in high positions that are not easy of access, as these sashes are hung on iron centres or pivots, higher up than their centres of gravity to allow for the weight of the cord attached to it, so that the window may be closed by its own weight from below by simply taking the cord off the cleat on which it is usually wound. These sashes require carefully fitting and the beads cut as in figure 428, otherwise the wind and rain will find a passage

Fig. 427.

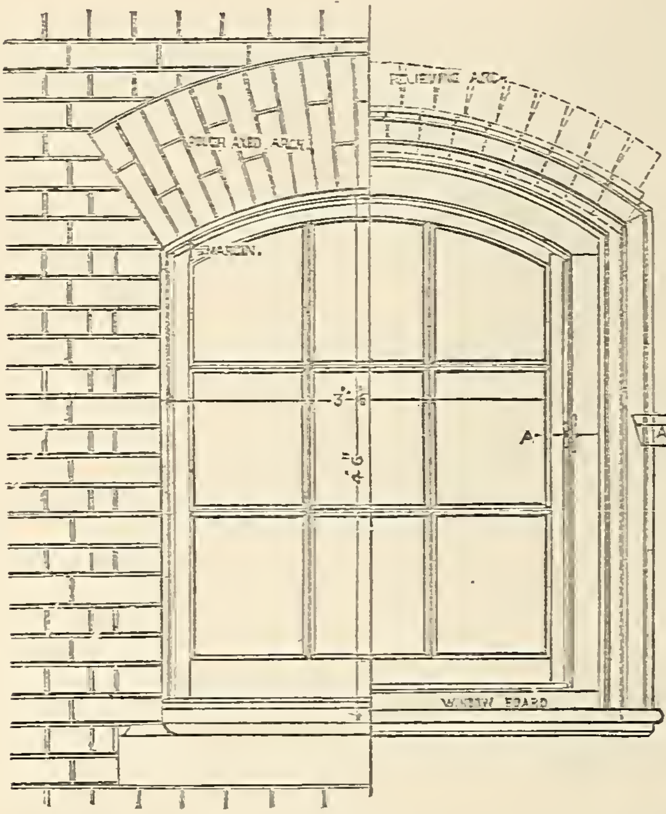
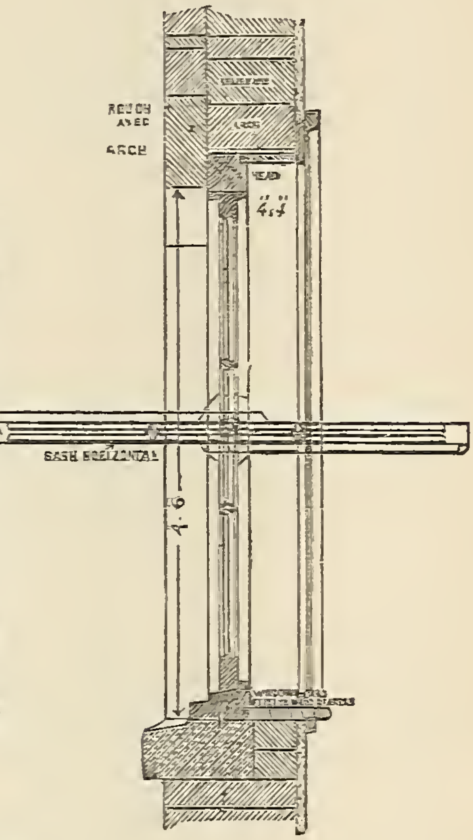


Fig. 428.



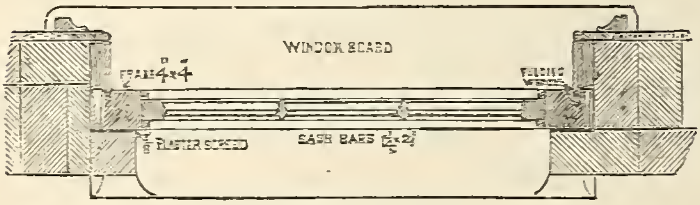


Fig. 426.

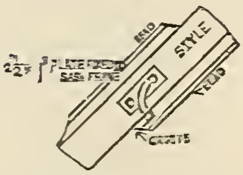


Fig. 429.

through the space between beads fixed on the sashes and the frames, and to admit sash being taken out grooves are sunk in beads, as shown in figure 429.

Sometimes the outside edge of the style is plough grooved so that when the sash is opened horizontally it may be taken out of the frame. This avoids the grooving of the beads that are fixed on the sashes, and, if the groove on the edge is no objection, greatly simplifies the work.

Sliding Sashes are said to be single hung when one sash is fixed, or without cords, weights, and axle pulleys, and the other is hung by the latter.

Double hung sashes is the name applied when both frames are suspended by cords, weights, and axle pulleys, figures 430 to 432.

Double Hung Sashes and Cased Frames. — Usually in dwelling-houses this method is adopted, owing to the efficiency in keeping out the weather, the ease with which the sashes can be raised or lowered, and the small amount of space occupied and required for working. The frames are made of linings enclosing a space (for the weights to move up and down, which balance the sashes), and consist of pulley styles, pulley head, oak sill, inside and outside linings, parting bead, inside bead, parting slip, back linings, angle blocks, brass axle pulleys, and are known as cased frames or boxings. There are two sashes, top and bottom, which consist of top and bottom rails, meeting rails, styles and bars, which are suspended by cords and weights. Figure 432 shows an opening filled in with double hung sashes and cased frame, having rebated meeting rails, to prevent sash fastener being opened from outside, a deep bead shown in section by dotted lines, to allow bottom sash to be raised about two inches so as to admit air without draught, and the vertical sash beads fixed by screws in cups to allow them

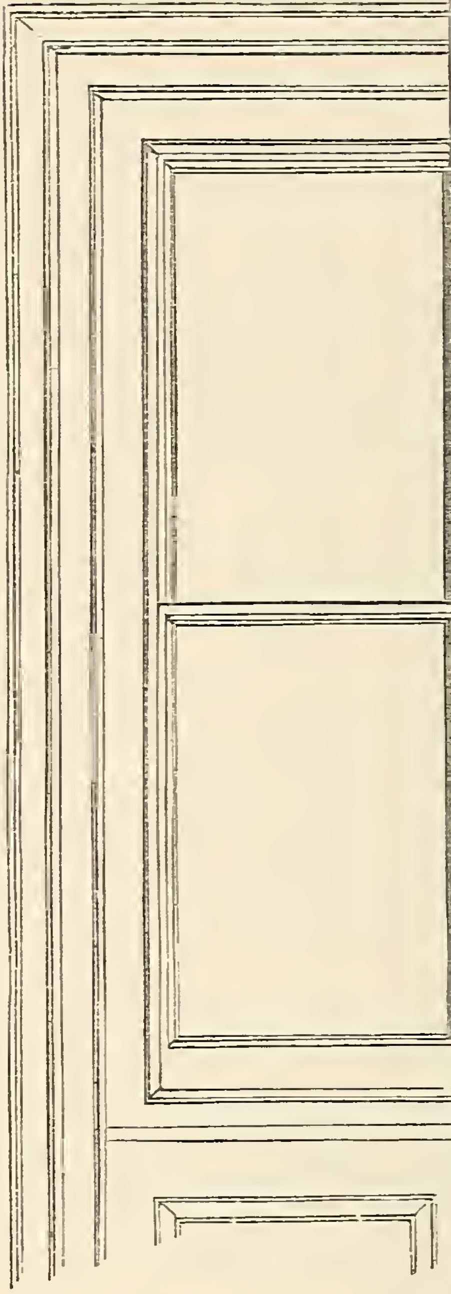


Fig. 431.

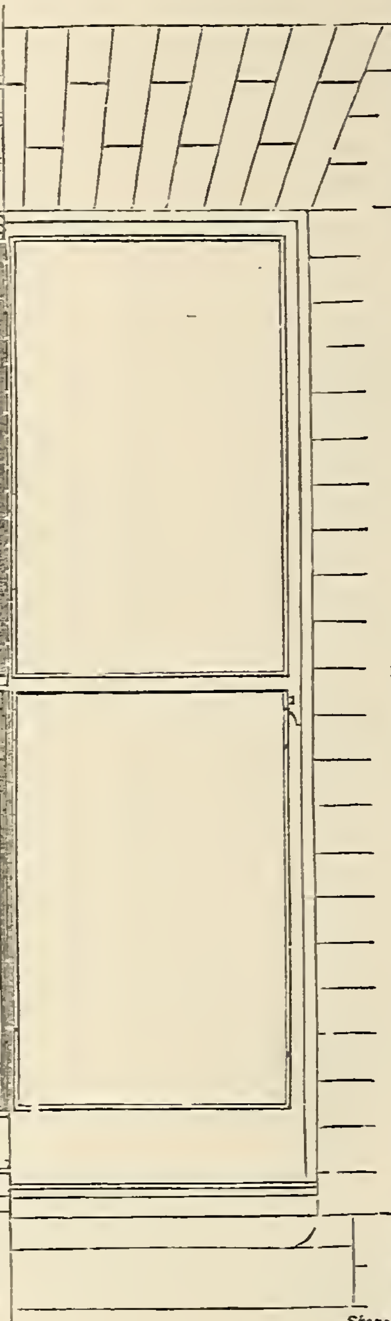
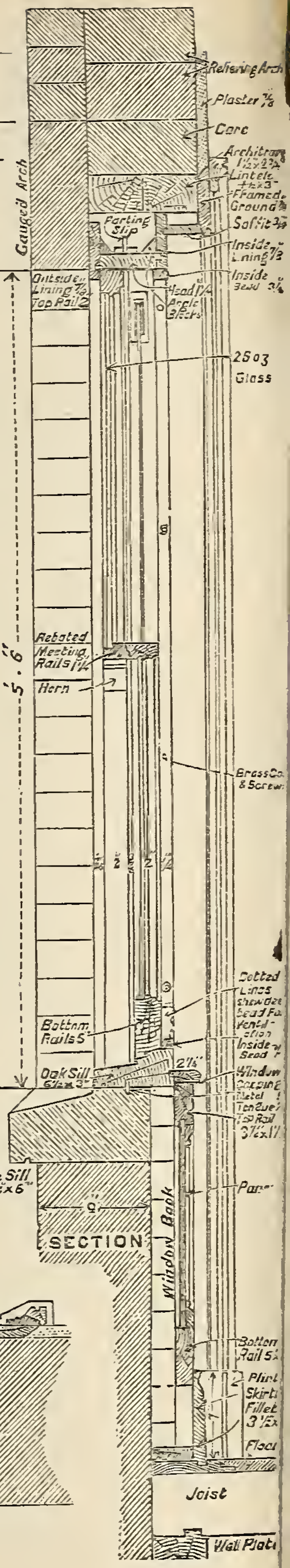


Fig. 432.



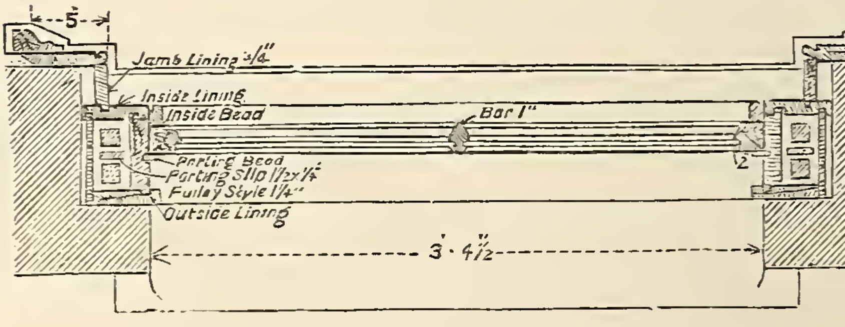
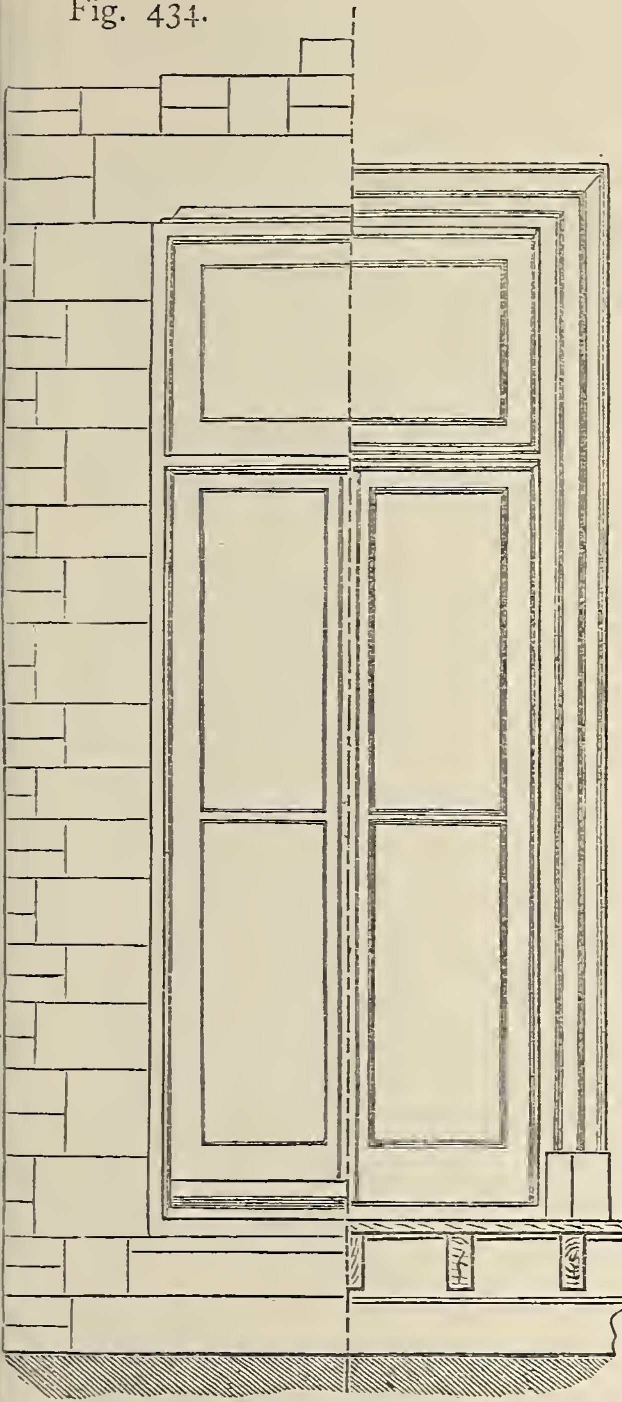


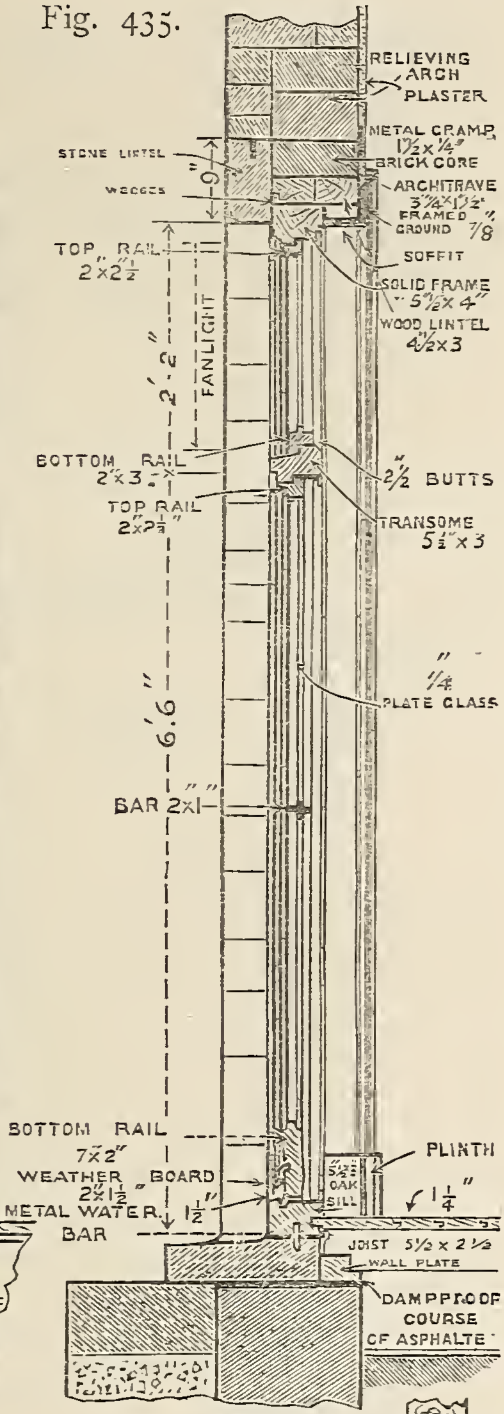
Fig. 430.

Fig. 434.



ELEVATION

Fig. 435.



SECTION

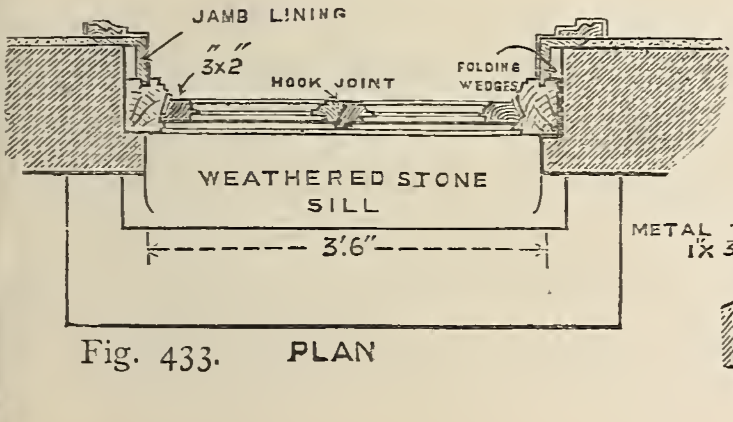


Fig. 433. PLAN

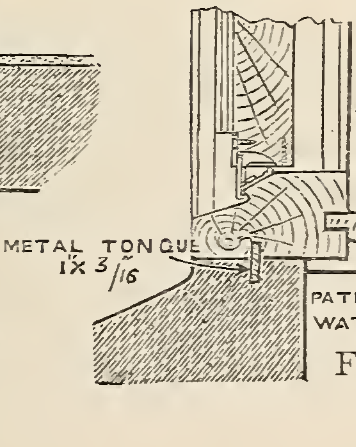
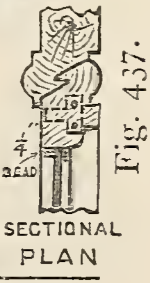


Fig. 436.



SECTIONAL PLAN

Fig. 437.

to be taken off and re-fixed for repairs or window cleaning, without any damage to bead or frame.

Casement Sashes and Frames.—When sashes are hung by one of their vertical edges, they are called casement sashes. It is a method most commonly employed on the Continent; they are convenient to be used as doors. The sashes and frames may be constructed to open outwards or inwards.

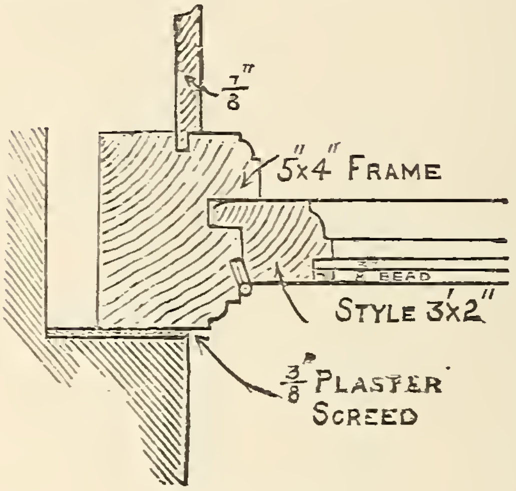


Fig. 438.

Sashes opening outwards present no great difficulty in obtaining watertight joints, but have this objection, that if a sash should happen to be left open, without being secured, the wind may act upon it and smash the glass, which in high situations would be dangerous. The joints in sashes opening inwards are very difficult to get wind and watertight, and but for this objection would undoubtedly be more frequently used, as they possess the advantage of being much easier to clean than any other method of fixing sashes, and the danger consequent thereon is reduced to a minimum.

Sashes opening outwards.—The members of frames for these sashes are rebated from the outside, as in figure 438.

Sashes opening inwards.—Figures 433 to 437 give an illustration of a pair of casement sashes, opening inwards, in solid frames, showing a metal water bar on bottom rails, and is very effectual in withstanding a driving rain at the seaside, or in places exposed to the weather this becomes a necessity; in sheltered situations a wood water bar, as in figure 435, may be used. The outer meeting style has a projecting moulding worked on it, or in inferior work this may be planted on, to protect the vertical joints between meeting styles. The hanging styles have a tongue worked on to fit into grooves sunk in the posts, and they are secured on the inside by bolts. Sometimes an espagnolette bolt is employed, which combines handle, top and bottom bolts, and the sash may be loosened or closed by one turn of the handle. Building Plate No. 21 gives enlarged details of casement sashes opening inwards.

CHAPTER XII.

PLUMBING.

Coverings.—The external work of a plumber chiefly consists in making exposed surfaces on roofs watertight. This he contrives to do by means of sheet lead, which, laid successfully, far surpasses for flats, gutters, flashings, etc., any other material, and combines lasting and waterproof properties. Lead coverings in towns may be said to be more economical than zinc. Zinc lasts well in the pure air of the country, but when exposed to the deleterious effects of the sea air, or the atmosphere of large towns, is readily destroyed.

Lead, as used by the plumber for external work, is obtainable in two forms, cast and milled.

Cast Lead.—The lead is melted and cast into moulds in sheets of the required size, but may be obtained up to 20 feet in length and 7 feet in width. It is very durable under great changes of temperature, and, being very hard, is suitable to positions where subjected to traffic, but it is subject to flaws and sand holes.

Milled Lead.—Sheets of lead are cast and passed through rollers; it may be obtained in lengths of 35 feet and widths up to 9 feet. It is more uniform in thickness than cast lead, and is better adapted for works where much bending and bossing is required to be done; it is not subject to the sand holes and flaws as is cast lead, but is not nearly so durable for roof coverings, nor is its resistance to wear equal to that of cast lead.

Laying Sheet Lead.—The ground to receive sheet lead, which is usually boarding, should be perfectly flat, and all the joints should be traversed by a plane to take away any projecting arrises, to prevent any unsightly ridges which otherwise, sooner or later, show through the lead, and which appear so unmistakably after wet weather. No sharp angles should be allowed, but all projections should be rounded off. The grain of the boarding on flats and gutters should always be in the direction of the current.

The soles of gutters are recommended to be formed by narrow boards 4½ inches wide, nailed with the heart side of boards upwards, so that the edges will press tightly against the bearers if the boards cast; the boards should be well nailed about 1¼ inches from both edges. The width of joints caused by shrinkage is obviously much less in narrow than in wide battens.

Care must be taken in fixing sheet lead that it is free to contract or expand, or that the pieces used are of such dimensions that the contraction or expansion will be unappreciable; this is practically satisfied at ordinary temperatures when the lengths of the pieces do not exceed 7 feet. The joints made by the free edges of lead must be so arranged that no water can pass through, or so that the wind is not likely to blow the covering up. If the above conditions are not taken into consideration in the fixing of sheet lead, the force of expansion and contraction will cause it to break away from its fixings, if it be in inclined positions, and form defective places, or to buckle and rise in the centre if it be on a flat.

The following table states the expansion by heat of the metals mostly used in construction, due to heat between the temperature of 32° and 212° Fahr. To find the expansion due to an alteration of temperature of one degree, divide the tabulated number by 180 :—

Cast Iron	1 part in 889
Wrought Iron	1 ,, 819
Steel, Untempered	1 ,, 927
Steel, Tempered	1 ,, 807
Lead	1 ,, 349
Zinc	1 ,, 340

The following are the weights of lead recommended for the various parts of external coverings :—

Roofs, Flats, and Main Gutters	7 lb. lead
Hips, Ridges, and Small Gutters ...	6 lb. ,,
Flashings	5 lb. ,,
Cisterns and Sinks, bottom	7 lb. ,,
,, ,, sides	6 lb. ,,
Soil Pipes	8 lb. ,,

It is important that the lengths of lead for any of the above purposes should not be greater than 7 feet.

Lead is usually described and specified by its weight in lbs. per superficial foot. The following table gives the thickness of milled lead in common use. The thickness, it may be noticed, is 17 thousandths of the inch for each lb. per superficial foot :—

Weight in lbs. per foot super.	Thickness in inches.	Weight in lbs. per foot super.	Thickness in inches.
1	0·017	7	0·118
2	0·034	8	0·135
3	0·051	9	0·152
4	0·068	10	0·169
5	0·085	11	0·186
6	0·101	12	0·203

The lengths of pieces of lead usually used in practice for gutters or flats should not be more than 7 feet, and the fall or inclination of the gutters should not be less than 1 inch in each sheet or 7 feet length. Cover and step flashings should not exceed 6 feet in length, and ridge pieces not more than 7 feet. Dormer cheeks if very large should be put on in two or more pieces. Large dormer tops should have a roll fixed upon them, but for small ones the lead has room to expand over the edges.

Nailing should not be resorted to more than is absolutely necessary. Bossing—that is, working the lead to the required angular form with box-wood dressers—is preferable to soldering in angles, such as the returned ends of gutters, drips, cesspools, the junction of ridges with brick walls, and in any position where the perpendicular part does not exceed 12 inches in depth. Soldering is very subject to cracking.

Lead Tacks.—These are narrow strips of lead, from 1 to 2 inches in width, for the purpose of fastening the free edges of flashings, ridge coverings, apron pieces, etc. They are sometimes termed *tingles.*

Passings are the distances pieces of lead lap over the adjoining continuing pieces, and occur in aprons for gutters, stepped flashings, ridge coverings, and in similar situations, wherever it would be unwise to have the lead in one continuous length. The usual length is 4 inches.

Raglets are the grooves or chases in brick or stone walls, usually 1½ inch deep, to receive the turned-in edge of the lead flashings.

Fixing for Flashings.—A small slightly inclined fillet of cement should be made on the lower surface of raglet, the lead flashing secured in same by lead wedges varying from 3 to 9 inches apart, and the open joint between the wedges pointed in cement.

Cover Flashings is the name given to the lead coverings over the turned-up parts of lead gutters or flats, and are usually about 6 inches wide, the object being to keep the part watertight, and to allow the covered sheet freedom to contract or expand.

Apron Pieces is the name applied to the lower horizontal flashing of a chimney shaft or wall penetrating a roof, as shown in figures 460 to 462.

Tilting Fillets.—These are usually of wood and triangular in section, and are used where the inclined surfaces abut against walls, to tilt the slates, and so carry water away from this weak part, which is usually protected and covered with lead flashings, as shown in figure 464. These fillets are also fixed under the eaves course of slates, so that they may lie close, and thus prevent the wind getting under them, as shown in figures 471 and 472.

Cement Fillets.—To save the expense of lead flashings, fillets, composed of equal portions of Portland cement and sand, are run along the junction of lean-to roofs with walls, but the cement sometimes shrinks, or breaks away, resulting in an open joint, consequently they fail to answer the purpose for which they are intended. Zinc soakers together with cement fillets are more effectual and are extensively used in cheap buildings, but are not nearly so durable as lead soakers and flashing.

Joints.—The joints most extensively used for lead coverings for external work may be classified as follows :—

Joints across the Flow or Current.—Lap and drip joints.

Joints parallel with the Flow.—Rolls, hollow rolls, and seams or welts.

Lap Joints.—These are used where the inclined surfaces of pitched roofs are covered with lead. The boarding should be placed at right angles to the inclination. The sheets of lead should be fixed between rolls, the upper sides being turned over the edge of boarding and nailed, so that the sheet is secured along the entire length of the top edge; this effectually resists the tendency to crawl down the slope and become detached, as is the case where only nailed to the boarding. The lower edge of upper sheet is made to lap over the top edge of the lower; if the covering is on a vertical surface, as shown in figure 439, a 4-inch lap would be sufficient; but if the surface has an inclination of not less than 45°, a 6-inch lap would be necessary. If inclination is at less than 45° the lap would require to be increased considerably, or a drip would have to be formed.

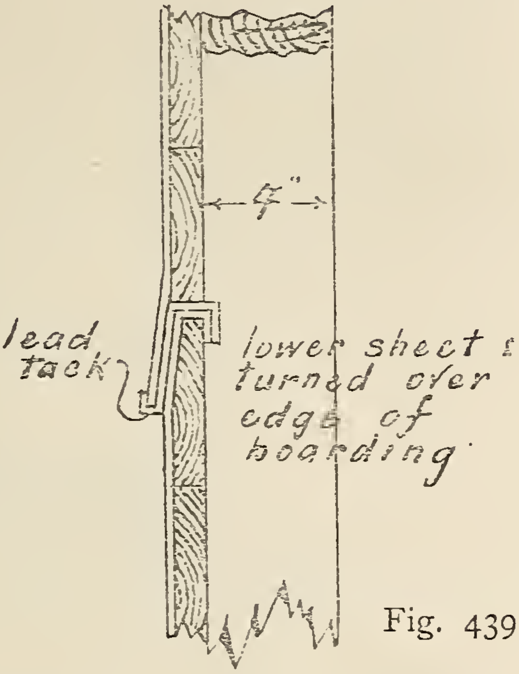


Fig. 439.

Drips.—Flat roofs and gutters are constructed of a number of plane surfaces slightly inclined and raised a short distance

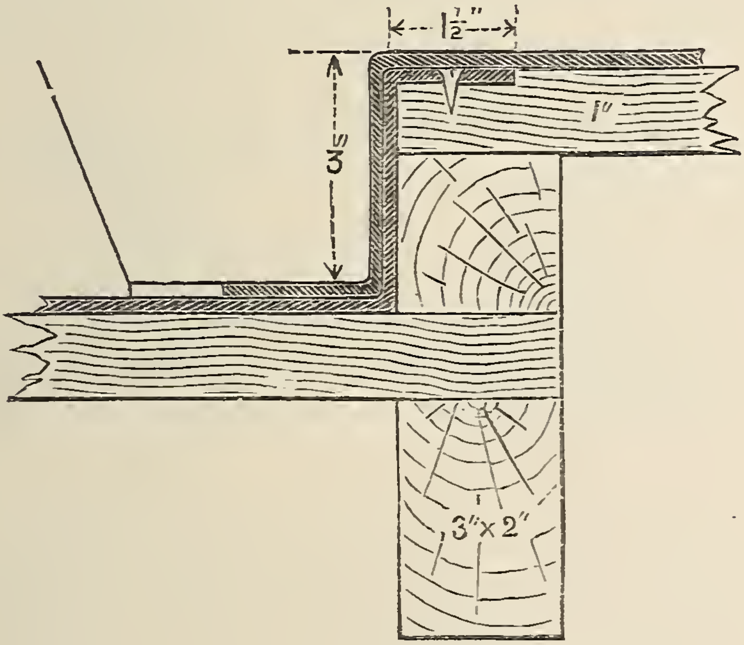


Fig. 440.

one above the other, forming, when finished, a number of low steps called drips, which should not be at greater distance than 7 feet apart. Drips should be made 3 inches in depth, as shown in figure 440, when they are sufficient to overcome the power of capillary attraction; but when made 2 inches or less, they should have a groove formed, as shown in figure 441, to resist that force. For economical reasons, drips in gutters are often made not more than 2 inches deep.

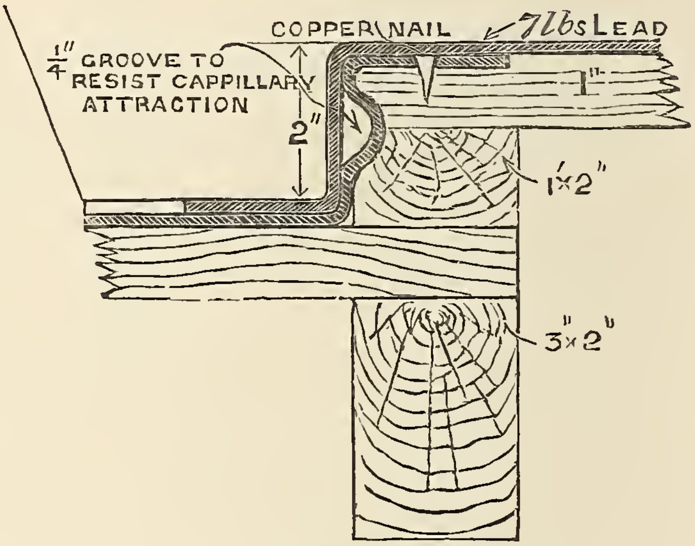


Fig. 441.

Rolls.—On flats, or at the ridge of two opposite slopes of gutter or roof, wooden rolls from 1¾ inch diameter and upwards are fixed at the joint. Sheet lead is dressed round the roll and well into the angles to obtain a firm grip, as in figure 443. Some authorities recommend the joint to be made as in figure 442, the overcloak being cut off, as shown, to

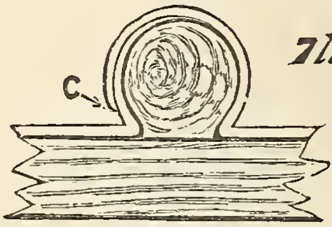


Fig. 442.

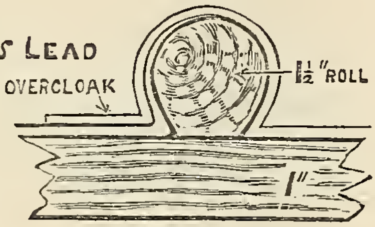


Fig. 443.

prevent capillary attraction, but this is far from being a good plan to adopt. Any traffic on the flat, or change of temperature, is likely to tear up or open the free edges, marked C. The section shown in figure 443 is the better way of constructing these, as the lead is not materially altered by change of temperature, if the lengths used do not exceed the tabulated dimensions, and is well adapted to withstand any walking upon it when repairs have to be made to the roof.

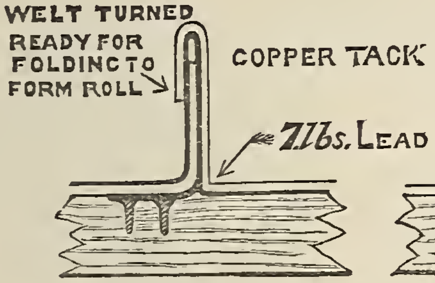


Fig. 444.

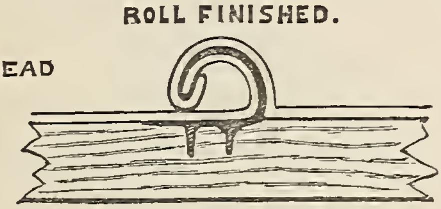


Fig. 445.

Hollow Rolls.—The method of forming rolls without a wooden core has been very extensively used on large buildings, cathedrals and abbeys, especially on those that were built in the mediæval ages.

To make a hollow roll, a copper or lead tack, about

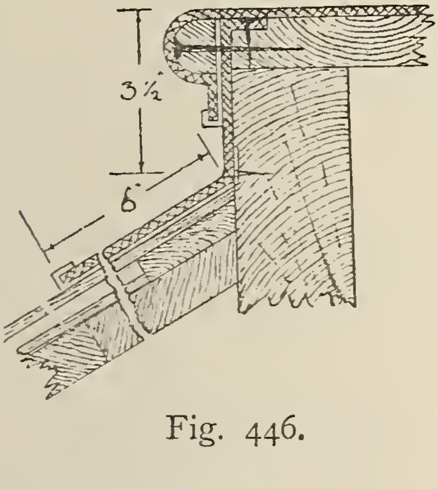


Fig. 446.

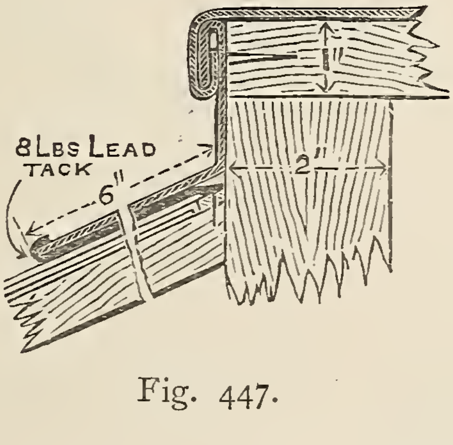


Fig. 447.

6 inches long and 2 inches wide, is secured by two screws to the boarding, about every 2 feet apart, the lead is turned up, as shown in section figure 444, and is then ready to be folded over. It is then dressed to enclose a hollow, as in section

figure 445. This is a good method of forming rolls, but not suitable for positions where any traffic is likely to come upon it.

Nosings.—At the boundaries of flats adjoining sloping roofs, or at the intersection of two differently inclined surfaces, as at the curb of a mansard roof, the lead covering may be terminated as a nosing, the object being to secure the edges of the lead and yet allow it to shrink or expand freely. Figure 446 shows a flashing of 6 lbs. lead laid on slates, and dressed against the vertical boundary of flat. A wood nosing is nailed over the top edge of the lead, thus firmly securing the flashing, and the lead covering of flat is then dressed round the nosing. The lower edge of flashing is secured from being torn up by the wind by means of lead tacks, thus avoiding the necessity of soldered dots, and admitting of the flashing expanding and contracting.

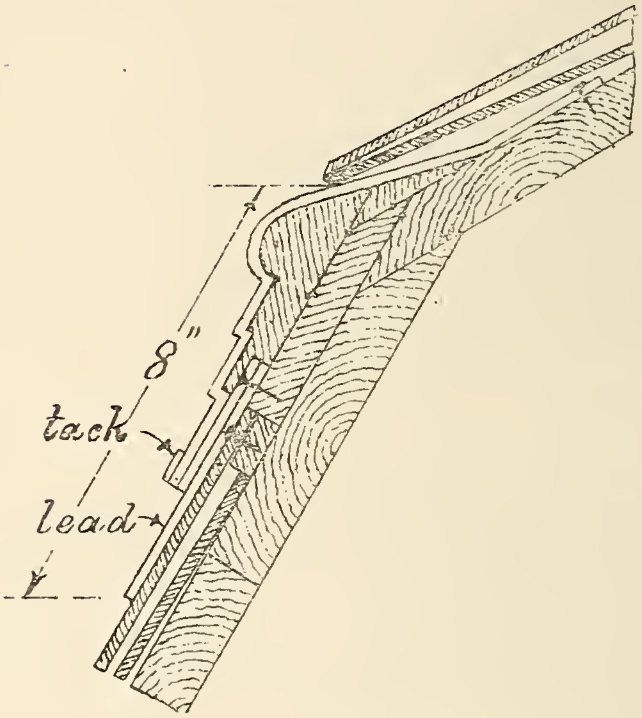


Fig. 448.

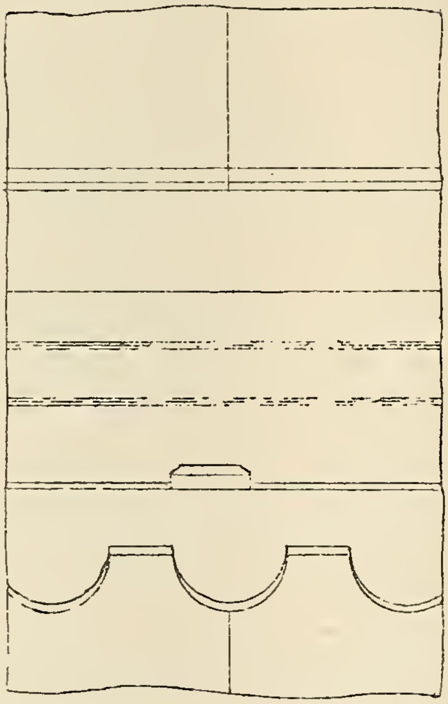


Fig. 449.

Figure 447 shows a flashing secured by copper nails instead of being covered by a wood nosing, and flat welted nosing is formed as shown in the figure.

Figure 449 is an elevation, and 448 a section showing the method of forming nosing for the curb of a mansard roof.

Seams.—The joints with the current on vertical surfaces, may be constructed as flat welts or seams, which consists in fixing lead or copper tacks about every 2 feet apart at the junction of the lead sheets; the edges are bent up and turned over together, and then dressed flat, as shown in figures 450 and 451. For flat pitched, or horizontal surfaces, seams are not so good as rolls.

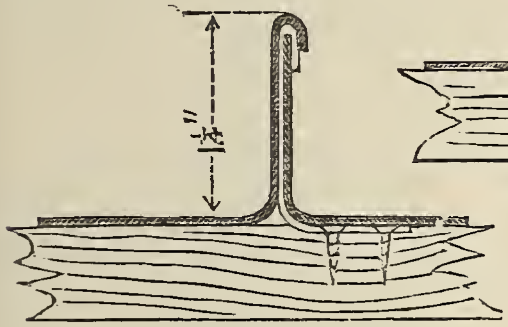


Fig. 450.

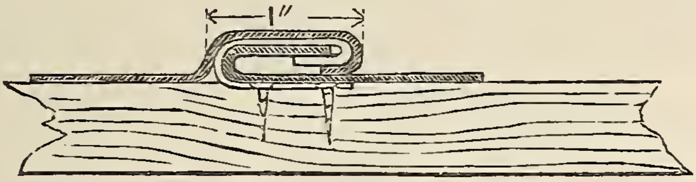


Fig. 451.

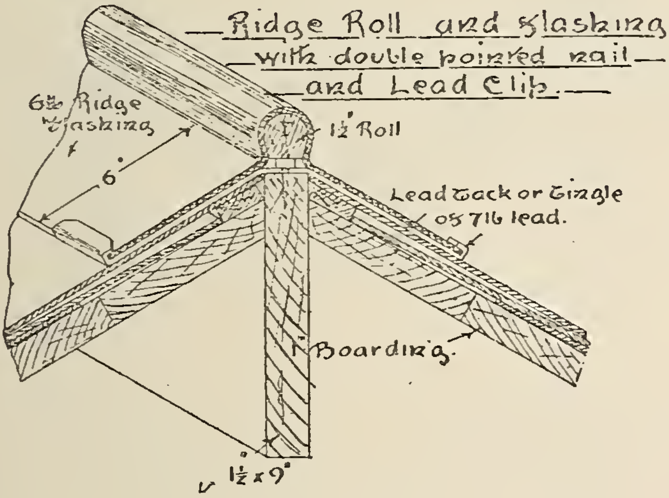


Fig. 452.

Welt.—When two thicknesses of lead are turned over and folded down together, they are said to form a welt, as in figure 451.

Ridge Coverings.—Six lbs. lead is the thickness usually adopted for ridge coverings; the lengths of the pieces should not exceed 7 feet.

The lead should be dressed over a wood ridge roll, which should not be less than 2 inches in height, and may be fixed in one of two ways: First, by double-headed nails, in which case the lead tacks that support the lower edge of ridge coverings pass beneath the roll, and is secured by it, as shown in figure 452; secondly, it may be nailed to the ridge, as shown in figure 453, the lead tacks being secured to the tilting fillet of the last course of slates.

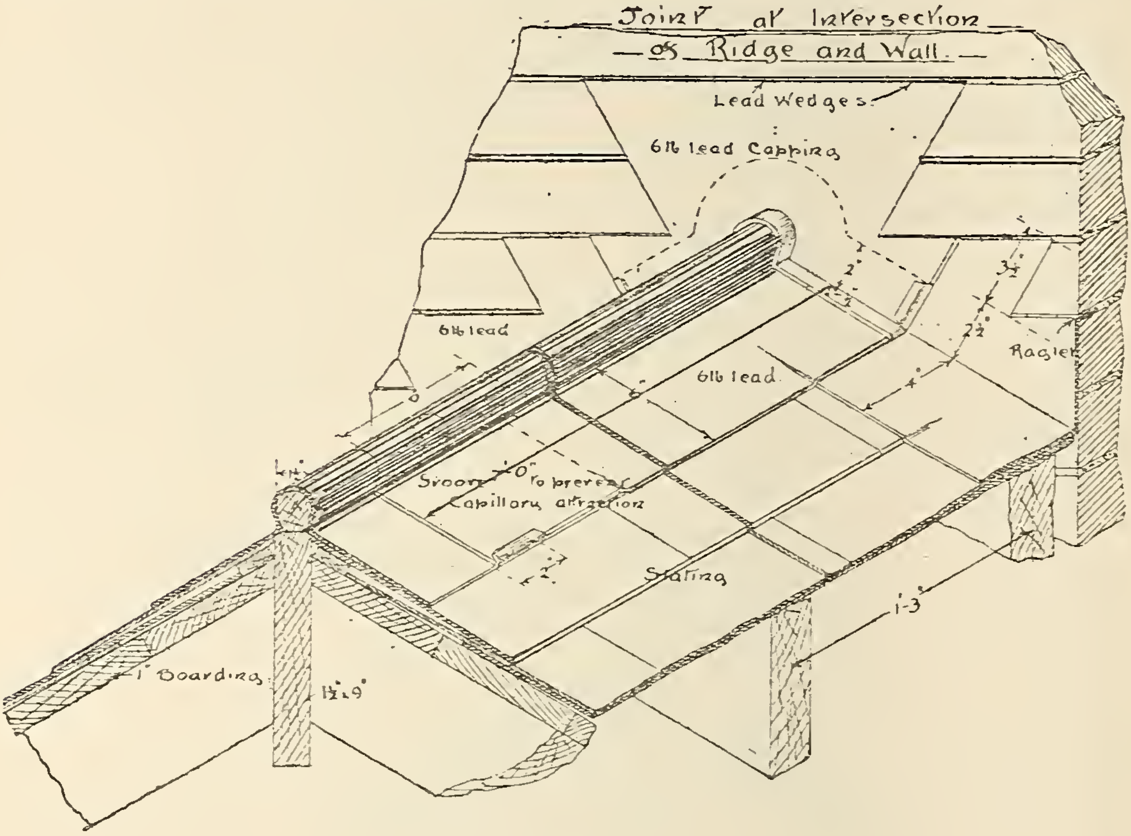
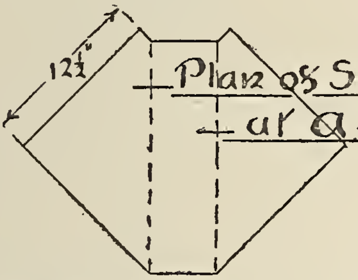


Fig. 453.

The lead covering should be dressed well into the bottom edges of the roll, and should extend for 6 inches down the slope on either side of ridge, the free edge being secured by the lead tacks.

A lap joint is formed at the junction of the ridge pieces. This has been objected to by some, on the grounds that water is liable to be drawn between the sheets by capillarity or driven in by wind; and if the ridge be not perfectly level, would drain in at that part. These objections may be obviated by forming a groove over the ridge roll, as shown in figure 453, the under piece of lead being dressed into it. Any water finding its way between the sheets on the sloping surfaces would fall on the slates and drain off.

Fig. 456.



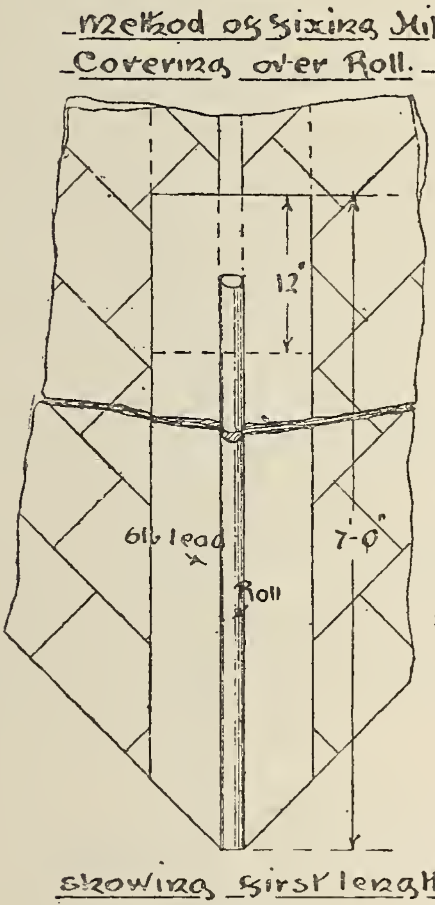


Fig. 454.

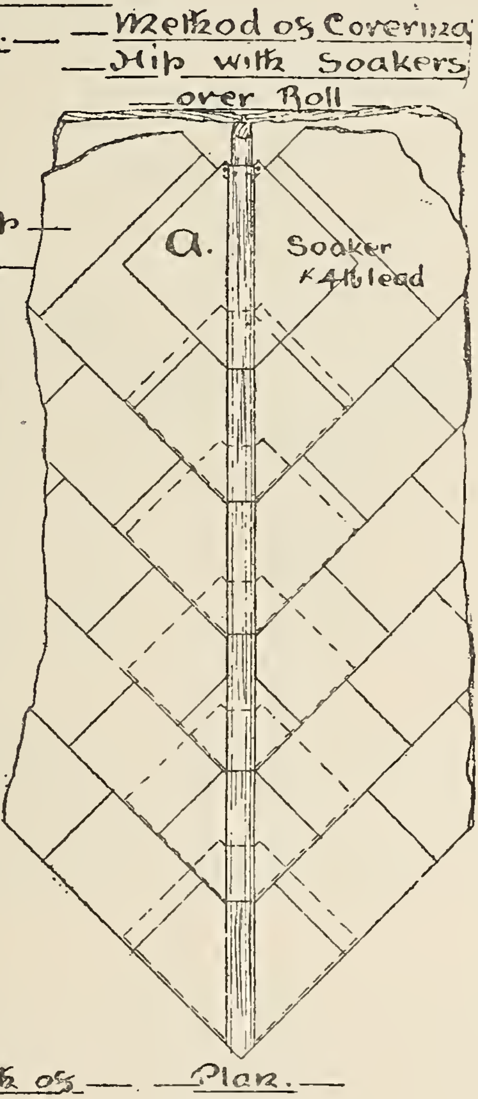


Fig. 455.

Difference between Valleys and Hips.—If the upper surfaces of the slopes of adjacent roofs include an angle less than 180°, or, in other words, form a hollow, it is termed a valley; but if the angle be greater than 180°, thus becoming a ridge or projection, it is called a hip.

Hips may be made effectually watertight in one of two ways. First, by dressing a piece of lead of the required width and not longer than 7 feet over a roll, and letting it project 6 inches down the slope on either side of roll in a similar manner to a ridge, provision being made to prevent the lead sliding down the slope, which is accomplished as follows:—The lowest piece of hip roll is fixed; the first piece of lead is laid on, extending 6 inches past, and being bossed over each end of roll, as shown in figure 454; the next length of roll is placed in position and fixed, its lowest extremity resting on the upper end of the first piece of lead, thus securely fastening and preventing any sliding. The second piece of lead is then proceeded with, lapping over the first piece 12 inches. Each length of lead should be supported at its centre by a lead tack, and the lower piece should be clipped over the upper at each lap joint. Secondly, the hip may be formed by soakers, which may either be fixed over a roll, as shown in figure 455, where they are visible, or the roll may be dispensed with, in which case there is a saving of lead.

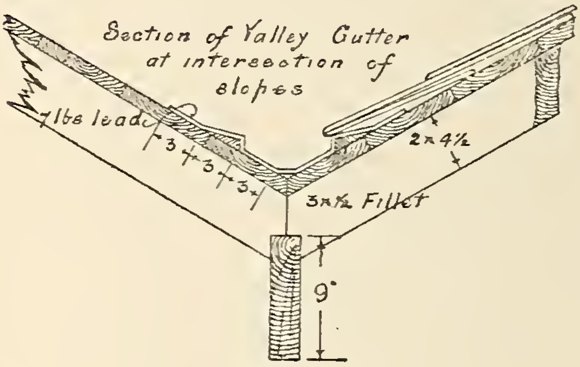


Fig. 457.

Figure 456 shows a plan of a hip soaker.

Valley Coverings.—In valleys, the coverings may be arranged to form a small gutter, small fillets being fixed on slopes of roofs to tilt the slates, as shown in section figure 457.

Stepped Flashings.—The joints between sloping roof surfaces and end walls are best protected by means of pieces of sheet lead, called step flashings, resting about

6 inches on roof and 6 inches against wall; the upper edges are turned 1½ inch into the raglets or joints of brickwork prepared to receive them, and are fixed as described in the paragraph on flashings. Figure 459 refers to this kind of flashing. To set out step flashings, first roll out the piece of lead, which should be 13 inches wide, then fold it lengthways in the centre, like the letter **L**. Draw a line, 2½ inches distant from the angle, on the stand-up side. This line is usually called the "water-line." The piece of lead should then be laid in its position on the roof, and the horizontal joints in the brickwork transferred to the lead between the top edge and the water-line. Next draw lines from the points where the horizontal lines cut the water-line, to the point where the horizontal line immediately above cuts the outer edge of the piece of lead. Draw other lines 1½ inch distant, parallel with and above the horizontal lines. The small triangular pieces of lead above these last lines to be cut out with a knife. The pieces between the parallel lines to be folded and wedged into the raglets of the brickwork.

Raking Flashing is the name given when the turned-up edge of a flashing is secured to a chase or raglet, cut parallel to slope of roof. This method is adopted for stone walls adjoining sloping roofs.

Flashings for Chimney Stacks.—Figures 458—465 show the mode of preventing any leakage through the joints on the four sides of a chimney stack; at the upper end by means of a gutter; at the sides by fixing stepped flashing or secret gutters; and at lower end with an apron piece and using lead wedges and tacks, as shown in figures 458 to 462.

Secret Gutters.—Sometimes flashings are arranged to form secret gutters instead of laying the lead on the slates.

DETAILS OF FLASHINGS FOR CHIMNEYS.

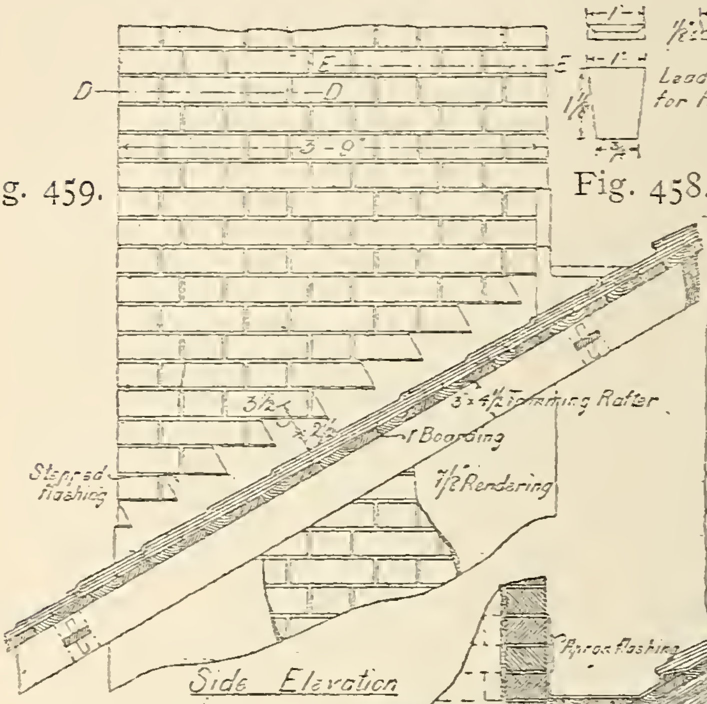


Fig. 459.

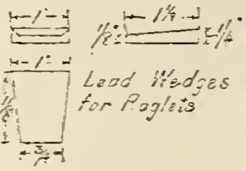


Fig. 458.

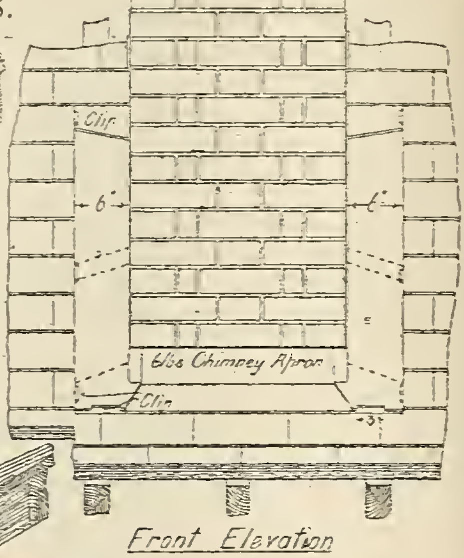


Fig. 462.

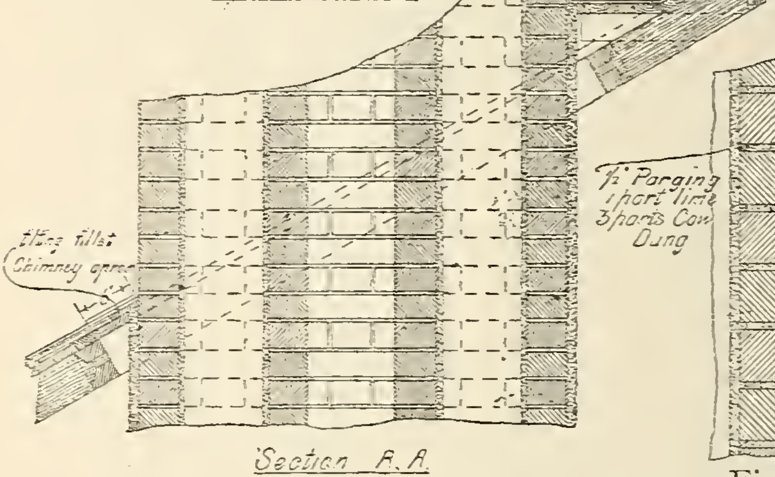


Fig. 460

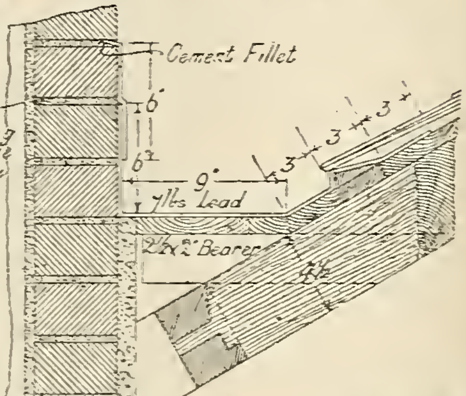


Fig. 463.

Enlarged Section A.A.

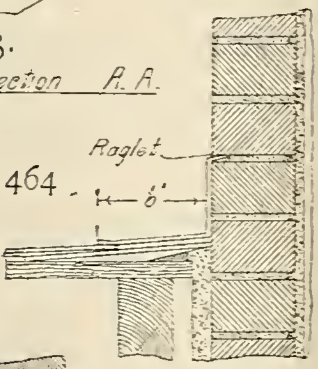


Fig 464

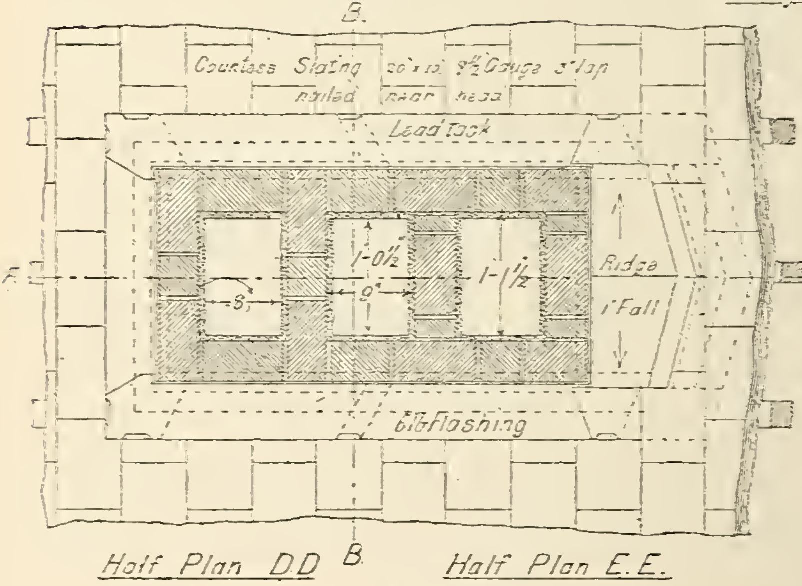


Fig. 461.

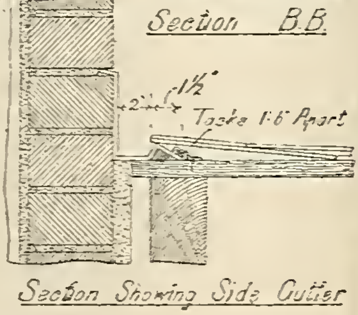


Fig. 465.

These secret gutters derive their name by reason of the slates hiding them from view. In some situations the slates are carried over the secret gutter so as to nearly touch the wall, thus protecting the lead from the sun; but the arrangement is bad in any position where leaves of trees or any rubbish might drift and choke the gutter. To obviate this, the gutter is better constructed, as shown in figure 465, where the tilting piece forms the depth of the trough, and the edge of the lead under the slates is bent to form a small welt to guide any water away that might pass over the fillet.

Figure 466 shows the boarding cut short on the rafters to give depth to the gutter, and a hollow welt is turned on the edge of the lead for the purpose given above.

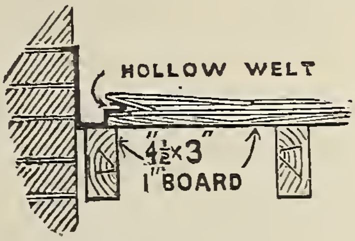


Fig. 466.

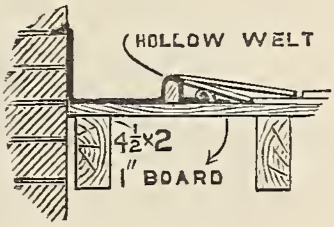
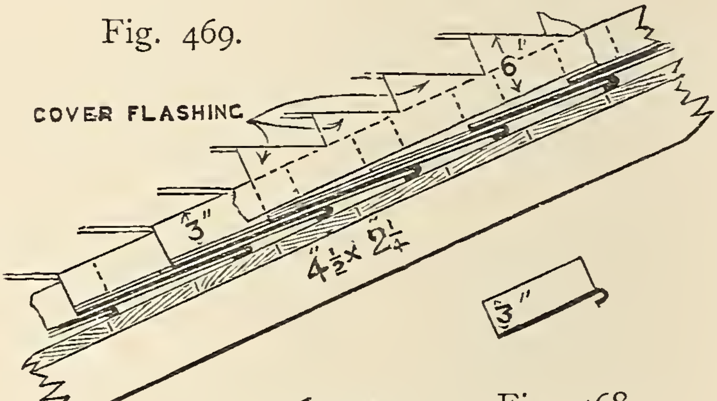


Fig. 467.

Side Gutters.—Water is often conveyed from the upper portions of mansard roofs by side gutters, as shown in figure 467, and is a better arrangement than using the ordinary flashing, as in the latter method the water in falling over has a tendency when driven by the wind to splash about and get under the flashings, especially where the intersecting slopes of roof and ridge is an acute angle.

Soakers.—The intersections of sloping roof surfaces with end gables or penetrating walls are made weathertight by means of pieces of lead termed soakers, fixed parallel to wall, and resting on slopes about 4 inches, and being turned up against wall from 2 to 3 inches, a cover stepped or raking flashing is fixed over the turned up edges. The soakers should be the length of the slates minus the margin and plus an inch for clipping over the heads of slates. Figure 468 shows a soaker cut for Countess slates; and figure 469 is an elevation of soakers, fixed with a stepped cover flashing over them to prevent the water leaking between the soakers and the wall. This is better than ordinary stepped flashings, as the wind cannot blow the rain between the roof and wall in the same manner as when ordinary stepped flashings are used.

Fig. 469.



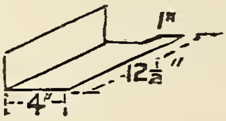


Fig. 468.

In some cases each soaker is allowed a length of 6 inches to turn up against the wall, and steps are cut and the edges tucked into raglet, as in ordinary stepped flashing. This is a good plan, but takes a longer time to execute.

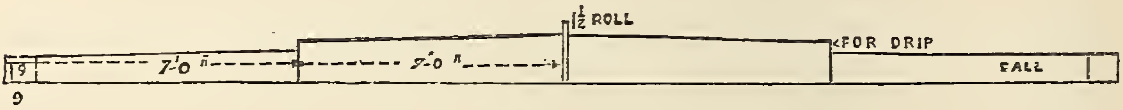


Fig. 470.

Gutters.—Rain water that falls upon roofs naturally runs to the lowest part, and provision must be made to carry the water away. This is generally done by means of gutters.

Gutters may be eaves or parapet gutters.

Eaves gutters usually consist of a small iron trough, as illustrated in figure 280. In a storm or great downpour of rain they do not, as a rule, accomplish the purpose for which they are intended, and it is not advisable to fix them on any side of a roof that overhangs the public highway. They are usually of cast iron, but should be fixed under the direction of the plumber.

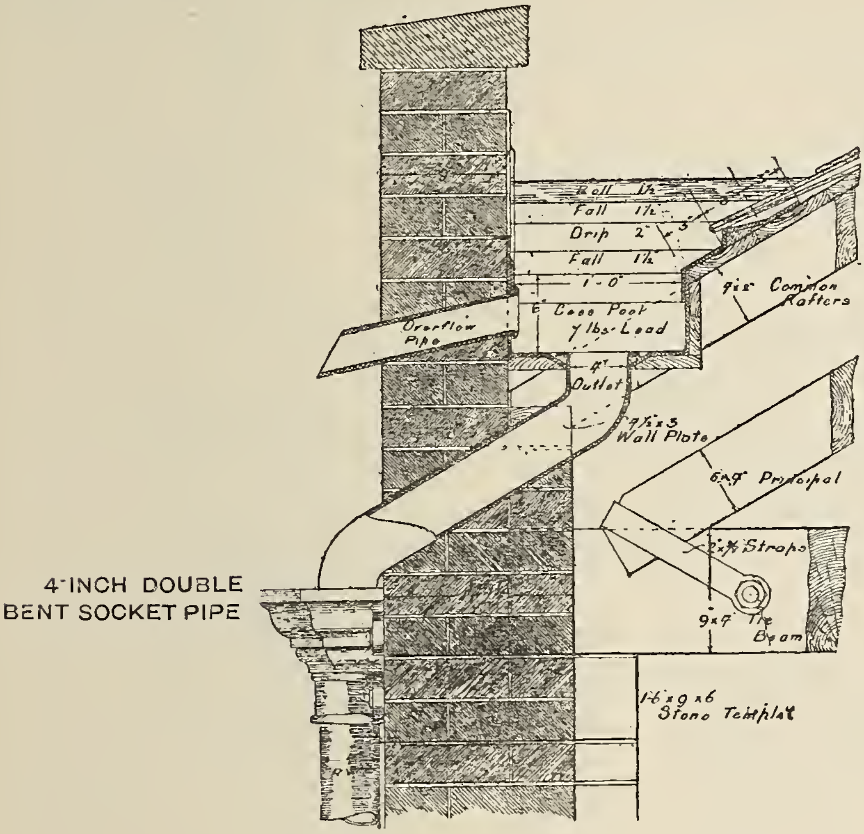


Fig. 471.

If a roof slopes toward the public highway, it is recommended to construct a parapet gutter as a guard against slates, tiles or snow falling into the street.

Parapet Gutters.—Gutters on the outer side of which a parapet wall is constructed are named parapet gutters, and may be parallel or tapering.

Tapering Parapet Gutters.—Parapet gutters are of irregular width where their plans are as shown in figure 470. This suits the construction of roofs where the common rafters rest on wall plates. Figure 471 shows how to obtain the required widths of sheet lead at the different positions in the gutters.

Parallel Parapet Gutters.—Roofs constructed with the common rafters resting on a pole plate fixed some distance away from the parapet, are termed parallel gutters, as shown in figure 472. The pole plate must be sufficiently deep to allow for all necessary falls and drips, which are required equally as much in this method as when the ordinary tapering shaped gutters are used. The timbering for this construction is more expensive than in the ordinary shaped gutters.

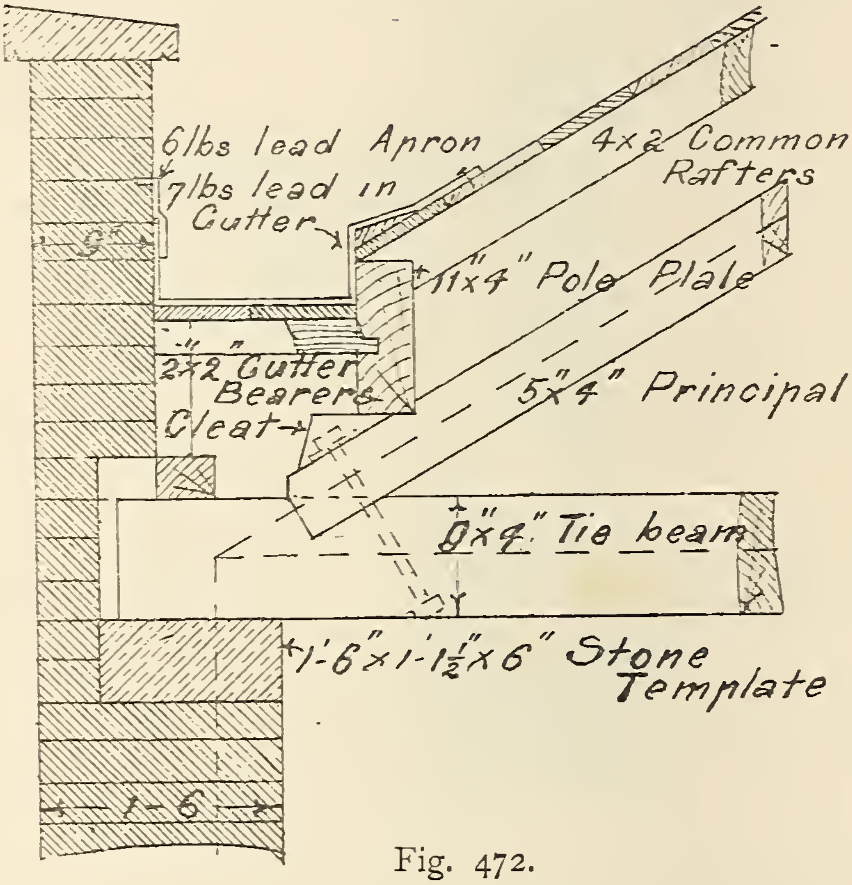


Fig. 472.

Tapering Valley Gutters.—Gutters constructed between the slopes of two adjacent roofs are called valley gutters, and may be taper shaped when the construction of roof is that of common rafters of adjoining slopes resting on the same plate. Figure 473 shows a section giving all necessary details for such gutter.

A similar section to this is often applied for sloping valleys, in which position no drips are required.

Parallel Valley or Box Gutters.—When a roof is constructed so that the common rafters of adjacent slopes are fixed to separate pole plates, parallel gutters may be made. If the depth of the gutter is more than 12 inches at the deepest end, it is usual to fix a lead apron, as shown in figure 474, instead of turning the gutters under slates, as in figure 472.

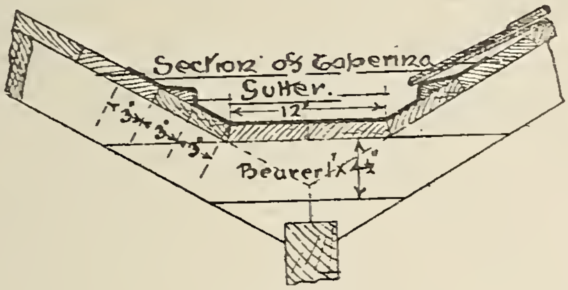


Fig. 473.

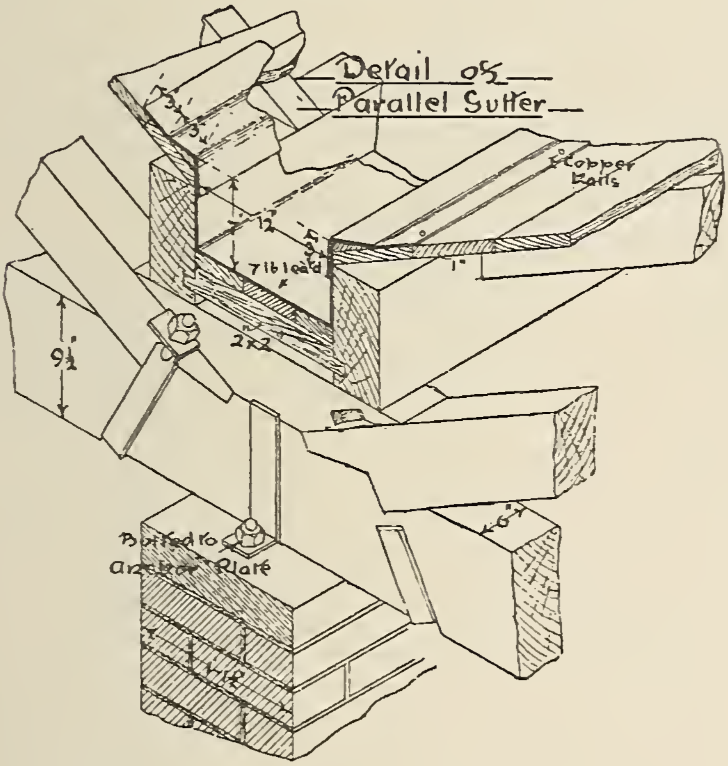


Fig. 474.

Gutters are constructed in M-shaped roofs where it is necessary to convey the water from the valley to one of the side gutters by forming timber troughs lined with lead connecting the gutters mentioned; they are then more particularly known as box gutters.

Snow Boards.—These are provided in all important gutters to preserve an uninterrupted channel to drain the water from the melting snow after a heavy snowstorm when the whole roof is covered. Under these circumstances the snow thaws on the underside first, through being in contact with the warm roof; but if the gutters and outlets be choked with frozen snow, that which is thawed will gain access through the joints in the roofing material. The snow boards as shown in figure 475 consist of a number of strips of 2 inches × 1 inch, placed in the gutter with their length parallel to the current of the gutter and spaced about $\frac{3}{4}$ inch apart; they are supported by and fixed to cross-pieces $4\frac{1}{2}$ inches × 2 inches. From the underside of these bearers a piece at least 2 inches wide is taken out from the centre and extends to within 3 inches from each end, forming an arch for the melted snow to flow through. These are especially necessary on all valley roofs.

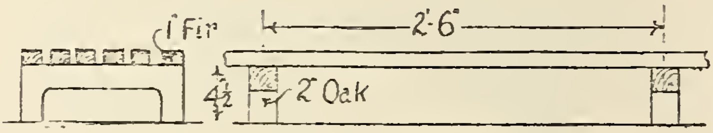


Fig. 475.

Snow Guards.—These consist of a low iron railing that should be fixed at the lower edge of all eaves roofs, to prevent large masses of snow slipping down the roof surface and falling over the eaves; they should be at least one foot high, and the rails should be large enough to thoroughly break the masses. In severe climates on eaves roofs these should never be omitted.

Burning In.—Lead cover flashings for parapet gutters are sometimes secured to the stone blocking course by being turned into a groove, or raglet, cut dovetail shape, on the top or front surface of the stone; molten lead is then poured into the groove which thoroughly secures the flashing to the stonework, as shown in figure 476. In some cases it is necessary to "set up," that is, to hammer in close with caulking tools which are similar to blunt chisels with a rounded end, and fill the groove, to ensure it being thoroughly secured, as the molten lead shrinks on cooling.

Soldered Dots.—Where large vertical surfaces have to be covered with lead, as on dormer cheeks, they are sometimes secured in the following manner:—Round hollowings, 3 inches diameter, are made in the boards; the lead is dressed well into these hollowings and screwed to the boards and studs (which latter are better for screwing to if against the required position). A tinned copper washer should be placed under the head of the screw to distribute the fixing over a greater surface of lead, so that when shrinkage or expansion takes place, the lead shall not be torn by the screw. The hollow is encompassed by a ring of soil (which is a composition of size, lamp black and chalk) to prevent the solder from adhering to the flush surface of lead covering. The hollow is then filled up level by means of solder, and is

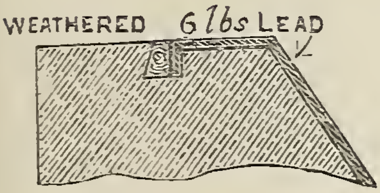


Fig. 476.

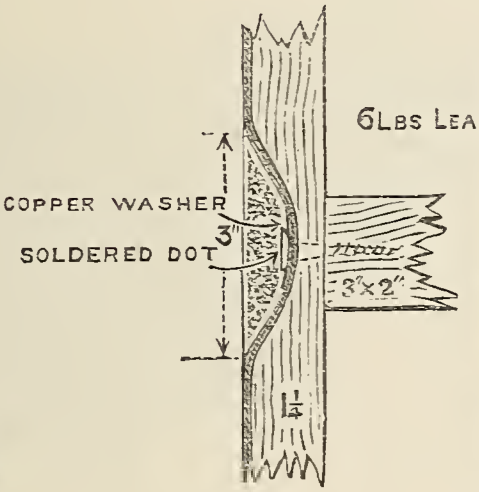


Fig. 477.

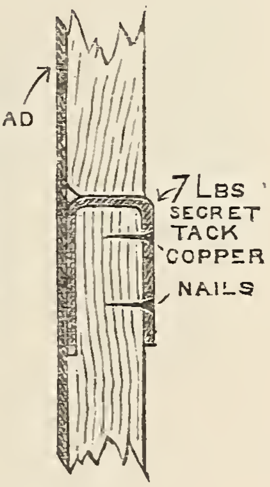


Fig. 478.

then known as a soldered dot, as shown in figure 477. Lead fixed in this manner is liable to cracks occurring near the soldered dots.

Secret Tacks.—A better mode of fixing dormer cheeks is shown in figure 478, where a lead tack is soldered to the back side of the lead covering. The loose end of the tack is passed through a slot cut in the boarding, and secured by copper nails on the inside. The tack, or secret tack as it is called, fixes the covering securely, and is not so unsightly as is the former method.

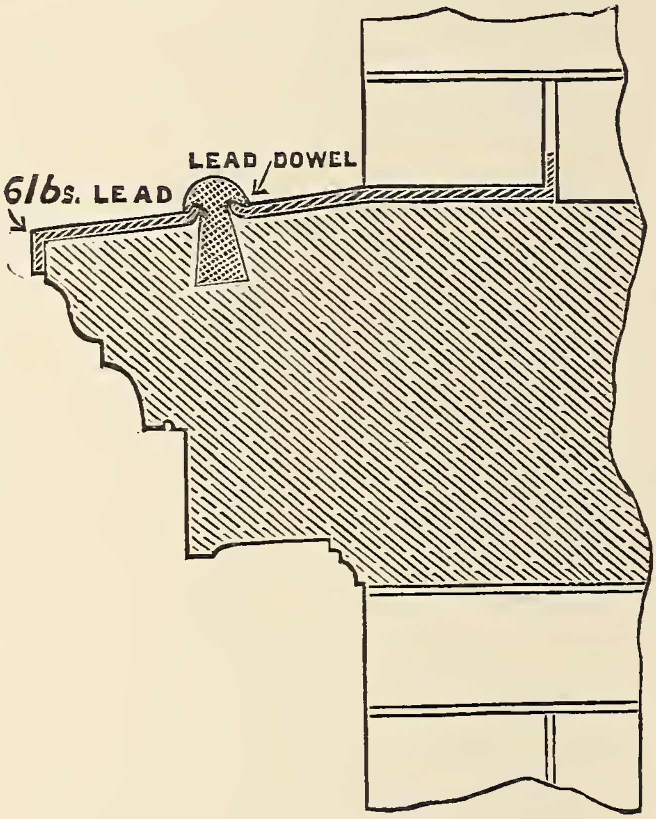


Fig. 479.

Lead Dowel or Dot.—Where exposed parts of stone cornices, strings, etc., that are covered with sheet lead require to be protected from high winds, lead is laid before the wall or blocking course is built. It may be turned up and built in the mortar joint, as shown in figure 479, or the lead may be passed through the wall, and turned down on the inner side. If laid after the wall is built, the lead may be dressed against the face of wall and tucked and wedged in a mortar joint that has been raked out to receive it. To prevent the free edge of flashing being torn up by wind, circular holes are made in the lead and surface of stone exactly opposite each other, the edges of lead round the hole being turned up slightly. An iron mould with a small hole through the top is pressed over the hole in the lead and stone, and molten lead poured through the mould, filling up the holes prepared to receive it, and also filling up the cup shape hollow of mould. This fixing is called a lead dowel or dot.

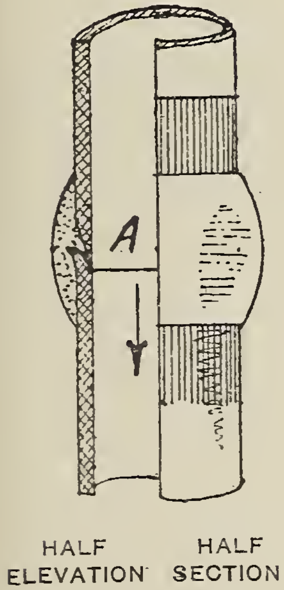


Fig. 480.

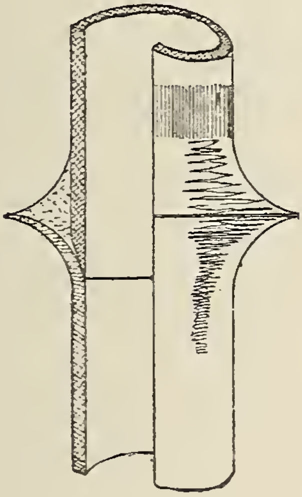
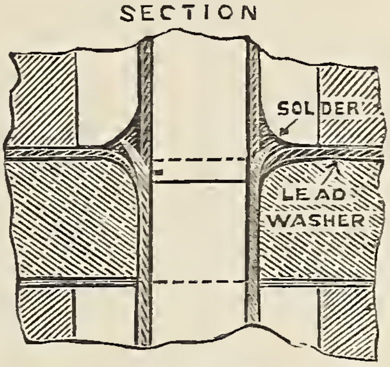


Fig. 481.

Fig. 482.



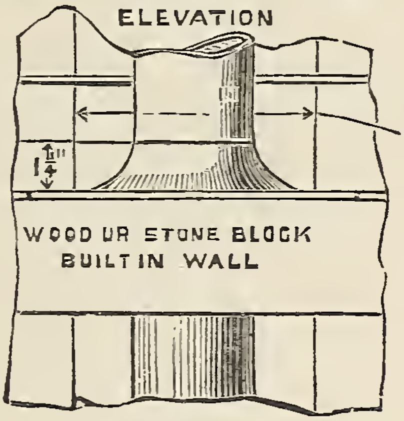


Fig. 483.

Wiped Joint.—The joints of all lead pipes which convey water under pressure should be wiped, as shown in figure 480. The process of making the joint is as follows :—The end of one piece of pipe is opened, as shown in figure 480, by means of a tan pin (a conical shaped piece of wood). The end of the remaining piece of pipe is filed to present a sharp edge on the internal face. The pipes are then fitted, care being taken to keep the internal surfaces true. The two ends are covered with soil for about 3 inches from the extremities. The pipes, for about 1½ inch from each end, are scraped bright with a tool called a shave hook. The pipes are placed together and secured in position; the molten solder is then poured on from a ladle and wiped round the joint with a piece of greased cloth. The solder adheres to the part that has been shaved and forms a sharp line about the pipe at its junction with the soil. The covered end marked A should be tapered in the direction of the current. Plumbers' solder is composed of two parts, by weight, of lead to one of tin.

Blown Joint.—This is an inferior kind of joint, used for connecting lead pipes together, as shown in figure 481. The ends are prepared and fitted as for the wiped joint and secured in position; a little flux, usually resin, is applied to the joint to aid in the fusion of the lead and the solder. The stick solder is used, and is melted by means of a blow-pipe flame, the solder only filling up the part of the pipe that has been opened out. It is the usual joint employed in composition pipes for gas, these being much lighter in section, and the maximum pressure on such joints being small.

Block Joint.—Where large pipes are fixed in vertical chases of walls that are prepared to receive them, the following soldered joint is sometimes constructed, and may be made as follows:—The top end of the lower length of pipe is passed through a circular hole, cut in a wood or stone block built in the wall, and the end of the pipe turned over a lead collar, which is placed upon the block. The upper length of pipe, with the ends prepared, is then arranged in its proper position over the lower one, and the joint soldered, as shown in figures 482 and 483.

CHAPTER XIII.

SLATING.

SLATES are used to cover roofs. They are considerably lighter than tiles and are not as absorbent, consequently the scantlings for a slated roof need not be as large as those for a tiled roof. They may be obtained in the market, of various dimensions as given :—

Dimensions of Slates.

	Inches.
Smalls	12 × 6
Doubles	13 × 7
Ladies (large)	16 × 8
Countesses	20 × 10
Duchesses	24 × 12
Princesses	24 × 14
Empresses	26 × 16
Imperials	30 × 24
Rags	36 × 24
Queens	36 × 24

But the sizes in common practice are as follows :—Duchess slates, 24 inches by 12 inches, for moderate flat roofs of $\frac{1}{5}$ pitch; Countess slates, 20 inches by 10 inches, for roofs of $\frac{1}{4}$ pitch; and Ladies, 16 inches by 8 inches, for roofs of $\frac{1}{3}$ pitch—the practice being the steeper the pitch the smaller the slate, and the more exposed the building the greater the pitch of the roof.

The following terms are used in slaters' work :—

Head ...	The upper or top edge of slate.
Back ...	The upper or exposed surface of slate when laid.
Bed ...	The lower or under surface of a slate.
Tail ...	The lower or bottom end of slate.
Margin ...	The part of each course of slates exposed to view.
Gauge ...	The distance apart nails have to be inserted on battens or boards ; this is required to determine the position of the battens to receive the nails by which the slates are secured.
Bond ...	Where a joint of two adjacent slates is immediately in the centre of the slate, the tail end of which rests upon them, the slates are said to bond.
Lap ...	The distance the tail of one slate overlaps the head of second course below, when slates are nailed near the centre, or the distance the tail of slate overlaps the nail hole of second course below when slates are nailed near the head. The lap in practice ranges from 2½ inches to 4 inches ; in this book it will be taken as 3 inches.
Holing ...	The piercing of slates to receive nails.
Sorting ...	Where the roof is to be covered by slates of different lengths, they are regulated to proper dimensions so that the largest slates may be nailed near the eaves, and the smallest at the ridge.
Eaves ...	The lower part of slating hanging over a wall.

There are two methods of laying slates :—

1st.—By nailing near the head.
2nd.—By nailing near the middle.

The groundwork to receive slates may be prepared in one of the following methods :—

1. *With Wood Battens* nailed horizontally across rafters fixed to the required gauge.

2. *With Close Boarding*—that is, the rafters are boarded over, and the slates nailed direct to the boards : this is a better method than battening.

3. *With Close Boarding and Asphalted Felt.*—The felt is a non-conductor and prevents radiation, and thus preserves a more equable temperature in the interior of buildings; it is also waterproof, and thus forms an extra precaution against damp.

4. *Close Boarding Felt and Battens.*—Where the slates are laid direct on the felt the latter is liable to decay, from want of ventilation; to prevent this, battens are laid horizontally on the felt to which the slates are fixed, thus allowing a circulation of air over the surface of the felt.

5. *Close Boarding, Felt, Vertical and Horizontal Battens.*—The last method is open to the objection that should any water find its way between the slates, as in the case of a broken slate, the water would lodge upon the horizontal battens and cause them to rot. To avoid this, battens are first laid on the felt to the slope of the roof, and fixed one over each rafter; horizontal battens are nailed to these again, and then the slates, so that should any water get beneath the slates it can run away: this leaves a larger air space, which is better for ventilating the battens and felt, also for preserving the temperature inside the building. This method should be adopted on all monumental buildings, and on roofs not easily accessible.

Gauge for Nailing Slates near the Head.—In this method of fixing slates, the nail holes are placed one inch from the head. The calculations to ascertain the gauge are as follows:—One inch plus the lap is deducted from the total length of slate, the first being due to the material above the nail hole, not being included in the lap, and the remainder is divided by two, which will give the gauge, and may be stated thus:—

$$\text{Gauge} = \frac{\text{length of slate} - 1'' - \text{lap,}}{2} \text{ which}$$

In Duchess Slates would be $\frac{24 - 1 - 3}{2} = \frac{20}{2} = 10$ inches.

,, Countess ,, ,, $\frac{20 - 1 - 3}{2} = \frac{16}{2} = 8$,,

,, Ladies ,, ,, $\frac{16 - 1 - 3}{2} = \frac{12}{2} = 6$,,

Figure 484 shows slates fixed by this method.

Gauge for Fixing Slates near the Middle.—The gauge is determined as follows:—The lap is deducted from the length, and the remainder is divided by 2, and may be stated thus:—

$$\frac{\text{Length of slate} - \text{lap}}{2}$$

In Duchesses would be $\frac{24-3}{2} = 10\frac{1}{2}''$.

,, Countesses ,, $\frac{20-3}{2} = 8\frac{1}{2}''$.

,, Ladies ,, $\frac{16-3}{2} = 6\frac{1}{2}''$.

Figures 485 and 486 show slates fixed by this method.

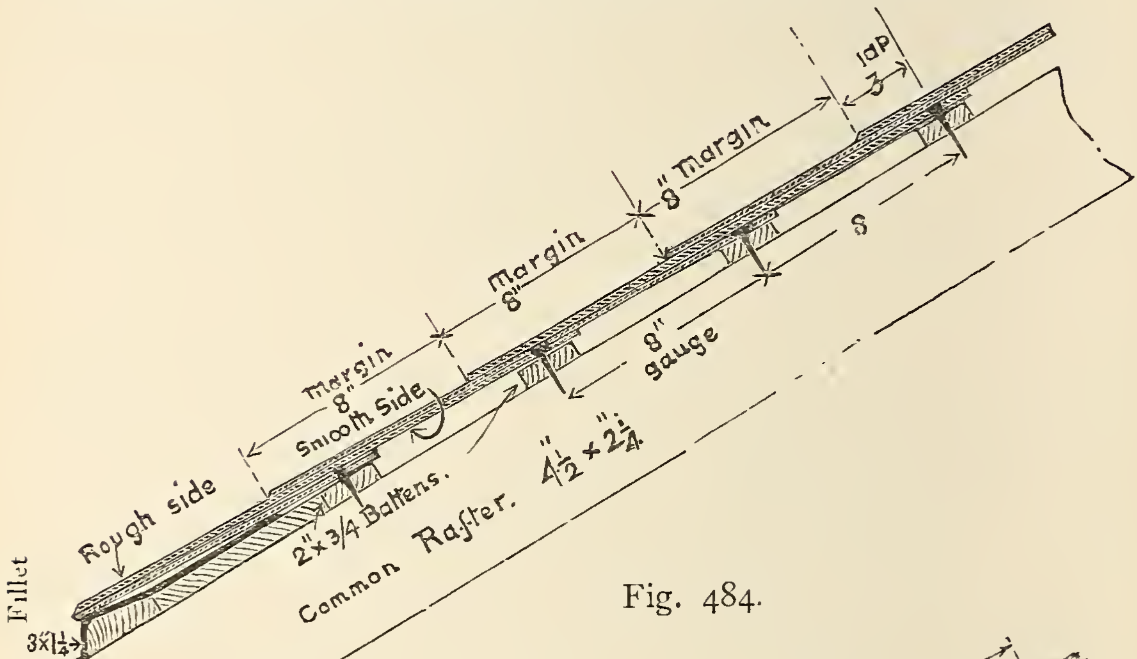


Fig. 484.

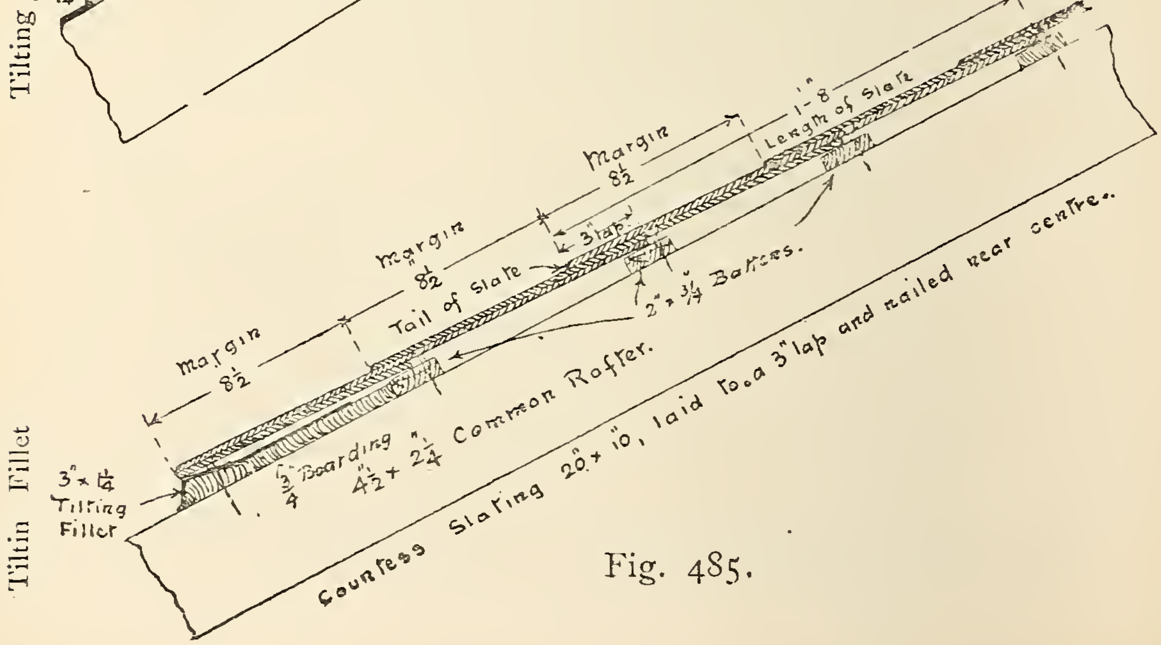


Fig. 485.

The slater determines the position of nail hole in the following manner: the lap is added to the gauge, and $\frac{1}{2}$ inch for clearance is allowed—measurements being taken from the tail. It may be stated thus:—

Gauge + lap + $\frac{1}{2}''$ = distance of nail hole from tail—

In Duchesses would be $10\frac{1}{2} + 3 + \frac{1}{2} = 14''$.
,, Countesses ,, $8\frac{1}{2} + 3 + \frac{1}{2} = 12''$.
,, Ladies ,, $6\frac{1}{2} + 3 + \frac{1}{2} = 10''$.

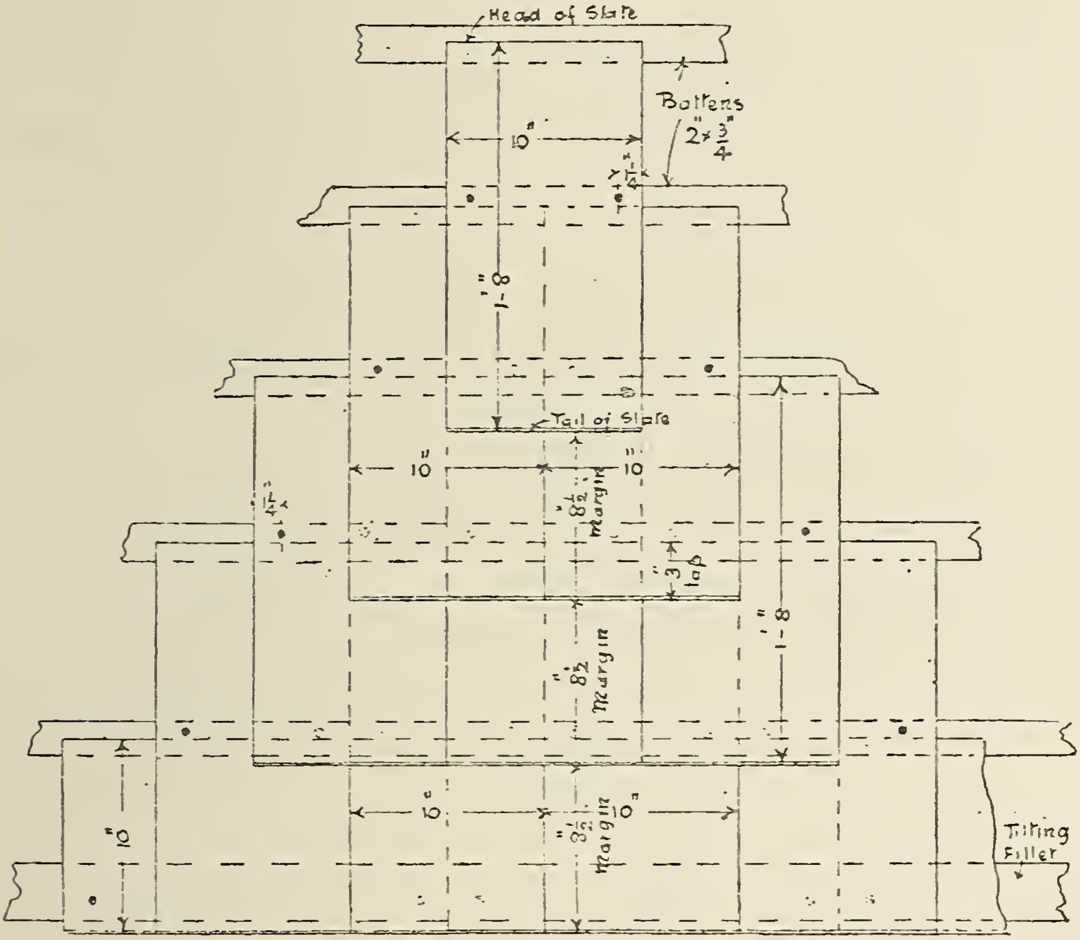


Fig. 486.

The distance of nail holes from the long edges in either method is $1\frac{1}{4}$ inch.

It can thus be observed that fewer slates will be required to cover equal areas of similar roofs by the method of nailing near the middle, than by the method of nailing near the head.

Advantages and Disadvantages—Of the two methods—are as follows :—Slates that are nailed near the head always have two thicknesses of slate over every nail hole, and the lap is practically 1 inch more than that which is calculated if the portion above nail holes is taken into account; but as this method requires more slates, it is therefore more expensive; and the long distance the nails are fixed from tail allows the wind to act with a greater leverage, which, in bad weather, sometimes strips the roof.

Open Slating.—Slates are sometimes laid so that the adjoining slates of the same course are a distance apart, about 2 inches, as in figure 487. A roof covered in this manner would not require nearly so many slates as the former methods; it is largely used for sheds or temporary buildings.

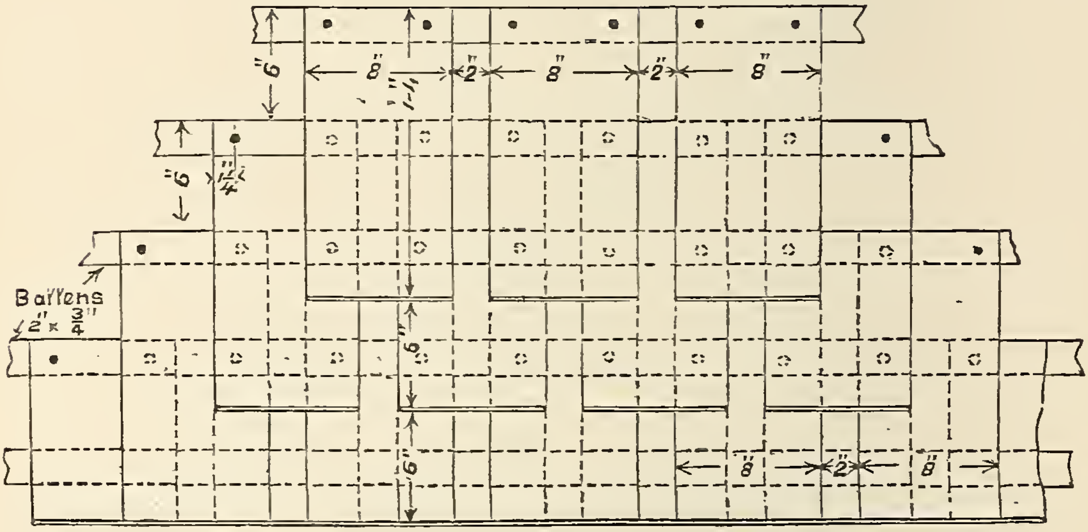


Fig. 487.

Doubling Eaves Course.—Slates are laid commencing at the eaves; the length of the slates should be as follows :—Gauge + lap + 1 inch in slates nailed near the head. In Countess slates this would be 8 + 3 + 1 = 12 inches, and nail hole would be 11 inches from tail, as shown in figure 484. Where slates are nailed near the centre, gauge + lap is the length; this would be in Countess slates $8\frac{1}{2} + 3 = 11\frac{1}{2}$ inches, and the nail hole would be over the centre of tilting piece, as shown in figure 485; but if the tilting piece is covered with lead, the nail holes would be made near the head.

Smooth Side of Slates.—Slates have one side smoother than the other, and a slater, in cutting on the smooth side, obtains a sharp edge, but on the rough side it is jagged. The doubling eaves course is laid with its smooth side up, the course above and all succeeding courses are laid with their smooth side down, so as to obtain a close joint to guide away the rain and wind, as in section figure 484.

Lead and Copper Tacks.—These are used for repairing defective slated roofs, the method being as follows:—The broken slates are removed, the nails being cut or drawn by a tool called a ripper, which has a thin blade about 2 feet long and 1 inch wide, being about 2 inches broad at the end, with a notch each side to receive nail; the tack is then hooked over the head of the slate below, the new slate is inserted, and the lead clip turned up over the tail. Two tacks should be used to each slate.

These lead or copper hooks are usually about $\frac{1}{2}''$ wide, the distance between the hooked ends being equal to the length of the slate minus a gauge.

Tilting Fillets.—To enable the tails of slates to fit closely against the slate below, and to form a close joint to keep out wind and wet, a tilting fillet or springing piece, as it is sometimes called, must be nailed under tail of first slate or doubling course. This will give all the slates a tilt, and cause them to bend on their tails. The slates will consequently be slightly apart, the less distance apart the better, so that, during repairs, they may be less likely to be broken. The tilting pieces are about ½ to ¾ inch thick, and tapered, as in section figure 472.

When roofs are battened, instead of a separate tilting piece, the first batten may be 1¼ to 1½ inch thick, and tapered, as shown in section figure 485.

Tilting fillets are also used against chimney breasts, to guide water away from walls, as in section figure 464, or at ridge, to compensate for the tilt of slate lost by its length being shorter than others, as in section figure 488, or in any position where slates are desired to be slightly raised.

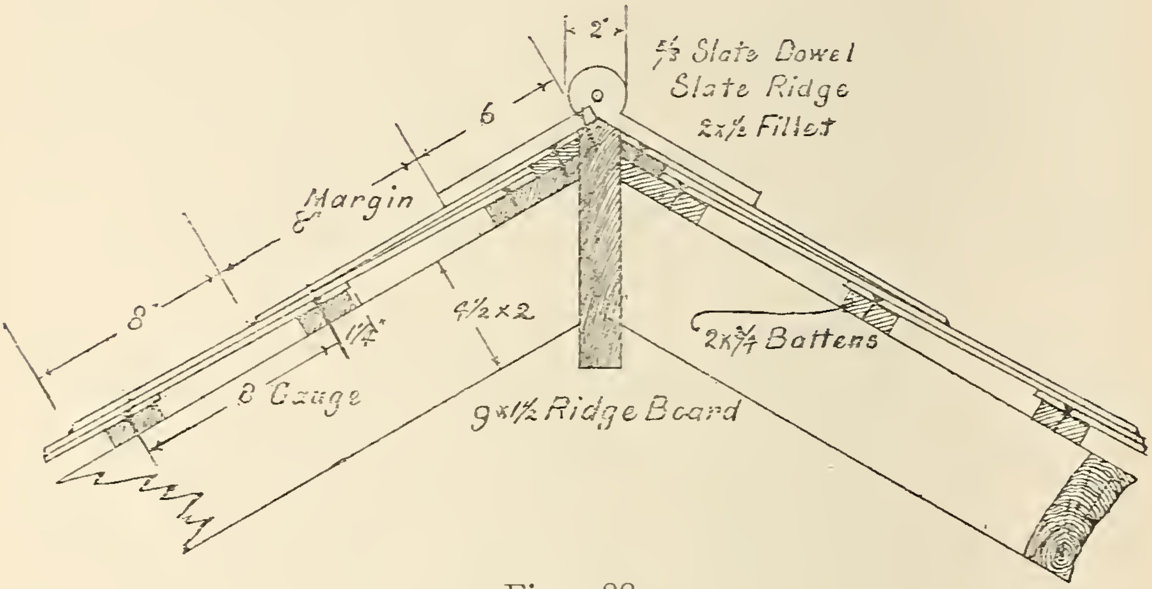


Fig. 488.

Tails of Slates.—Slates should be laid with their tails horizontal, but wherever taper-shaped gutters occur in roofs the side of the gutter nearest the ridge is not parallel with it, as shown in plan, figure 470. So the tails of doubling courses form an exception to this rule.

Slate Hips and Ridges are now much used in the place of lead to save expense. The slate ridges are holed and bedded in hair-mortar, the holes filled with white lead and secured with copper screws, and the adjoining pieces dowelled together with small slate dowels, as shown in figure 488.

Nails.—Slating nails have flat circular heads, have a sharp point on shank, and are made from 1¼ to 2″ long. There are four kinds in general use, viz., iron, zinc, copper and composition.

> (1). *Iron* nails may be either cast or malleable. The cast resist oxidation better than the malleable, but being brittle are inferior to the above, and are only used for cheap work. Malleable nails are first cast and then made malleable; they are often galvanized or painted to resist oxidation, but they are better when dipped while hot into boiled linseed oil, which method is frequently and successfully adopted.
>
> (2). *Zinc.*—Zinc nails are very soft and easily broken; they are not well adapted for driving, and are therefore wasteful and expensive to use.
>
> (3). *Copper Nails.*—These may be obtained as wrought or cast, are very soft, expensive, and are not much used.
>
> (4). *Composition.*—These are a mixture of zinc, copper and tin. The alloy is much harder than either the copper or the zinc, does not oxidise to any extent and is better adapted for driving; they should be employed on all important work.

SPECIFICATION OF SLATES.

The whole of the slates to be of the best quality, properly squared, free from spots, and of such quarries and colour as shall be approved by the architect. Each slate, when nails are used, to be holed near the centre of its length (or near the head) and secured with two strong nails for each slate, the third slate to overlap the first not less than three inches, and to bed flat upon the previous course. Upright slating to have four-inch laps and fixed to walls with four nails each.

In all descriptions of roof slating the eaves to be a double course of slates, the under course being cut to the required length.

The nails for Countess and Duchess slates to be not less than 1½″ long, and for larger slates to be not less than 2″ long.

If iron nails are used they are to be dipped while hot into boiled linseed oil.

EXERCISES.

BRICKWORK.

No.	Page.	Question.	No.	Page.	Question.	No.	Page.	Question.
1	252	1	17	291	1	32	264	7
2	255	1	18	291	2	33	267	8
3	255	5	19	291	3	34	269	9
4	258	1	20	294	1	35	296	9
5	261	1	21	294	2	36	299	8
6	264	1	22	297	1	37	299	13
7	267	1	23	297	2	38	254	11
8	270	1	24	300	1	39	257	10
9	273	2	25	261	5	40	281	8
10	276	1	26	267	5	41	293	10
11	279	1	27	270	6	42	284	12
12	282	1	28	273	6	43	285	6
13	282	3	29	291	5	44	287	12
14	285	1	30	300	6	45	288	2
15	285	2	31	260	9	46	290	8
16	288	3	...	...	...	...	...	...

MASONRY.

1	252	2	12	282	4	23	272	9
2	255	2	13	291	4	24	257	8
3	258	2	14	294	3	25	302	10
4	261	2	15	294	4	26	260	10
5	264	2	16	300	3	27	275	12
6	267	2	17	258	6	28	279	2
7	270	2	18	261	6	29	279	5
8	273	1	19	264	5	30	282	5
9	273	4	20	285	5	31	285	4
10	276	4	21	297	5	32	288	5
11	276	5	22	252	6	33	299	12

GIRDERS.

1	252	4	7	297	4	13	294	7
2	255	3	8	300	4	14	299	7
3	258	4	9	267	6	15	269	14
4	261	4	10	274	7	16	281	9
5	264	4	11	276	6	17	290	12
6	267	3	12	291	7	18	...	...

JOINTS IN CARPENTRY.

No.	Page.	Question.	No.	Page.	Question.	No.	Page.	Question.
1	252	3	7	282	2	13	279	6
2	258	3	8	285	3	14	267	6
3	261	3	9	297	3	15	254	9
4	273	5	10	300	2	16	297	4
5	276	2	11	270	5	17	279	3
6	279	4	12	300	5	18	281	14

FLOORS.

1	252	5	10	278	9	19	263	12
2	255	4	11	293	9	20	275	13
3	270	3	12	302	8	21	260	13
4	273	3	13	254	10	22	285	7
5	300	7	14	257	11	23	284	10
6	255	7	15	293	11	24	287	10
7	263	8	16	296	11	25	288	1
8	266	8	17	269	10	26	288	6
9	272	10	18	272	12	...	...	...

PARTITIONS.

1	294	5	3	260	11	5	278	13
2	272	11	4	266	11	...	...	...

WOOD ROOFS.

1	267	4	9	282	6	17	278	11
2	258	5	10	293	8	18	302	12
3	264	6	11	263	11	19	269	12
4	264	3	12	273	8	20	263	14
5	291	6	13	275	11	21	279	7
6	252	7	14	299	10	22	284	9
7	255	6	15	287	11	23	287	8
8	258	7	16	296	13	24	290	9

COMPOSITE ROOFS.

1	266	12	2	288	4	...	...	...

IRON ROOFS.

No.	Page.	Question.	No.	Page.	Question.	No.	Page.	Question.
1	270	7	6	299	14	10	266	14
2	278	10	7	302	14	11	287	13
3	294	8	8	254	13	12	284	14
4	281	12	9	260	14	13	290	13
5	293	13	...	...	...	...	...	...

JOINERY.

1	276	3	13	290	11	24	275	14
2	261	7	14	299	11	25	278	14
3	282	7	15	302	11	26	257	13
4	294	6	16	296	12	27	263	13
5	297	6	17	293	14	28	266	13
6	266	9	18	257	12	29	269	13
7	276	8	19	296	14	30	254	14
8	284	8	20	254	12	31	287	14
9	302	9	21	260	12	32	284	11
10	257	9	22	272	13	33	281	10
11	269	11	23	272	14	34	290	14
12	296	10	...	...	...	...	...	...

PLUMBING.

1	270	4	5	287	9	9	302	13
2	276	7	6	275	9	10	281	13
3	288	7	7	263	10	11	290	10
4	299	9	8	278	12	...	...	...

SLATING.

1	260	8	4	281	11	7	293	12
2	270	8	5	254	8	8	284	13
3	275	10	6	266	10	9	257	14

APPENDIX.

SCIENCE & ART SYLLABUS.

SUBJECT III.

BUILDING CONSTRUCTION.

As the object of this Course of Instruction is to lay the foundation of a sound knowledge of the principles, as well as of the practice, of Building Construction, and so lead the workman to labour with his head at the same time as with his hands, the teacher should not, necessarily, attempt to push the students through the whole of the subjects enumerated in this syllabus, but should limit the range of his tuition according to the time at his command and the intelligence of the pupils.

A larger number of questions will be set in the examination papers for the Elementary and Advanced Stages than the candidate will be allowed to attempt, so that he will, to a certain extent, be able to show his knowledge in such branches as he may, from circumstances, have paid special attention to. For instance, a student better acquainted with iron than wooden structures will be able to select a question on iron work, in preference to one on wood work. In order, however, to ensure that special attention shall not be given to work of one description only, a certain number of the questions given will be compulsory, *i.e.*, the candidate must attempt these, and unless he shows a sound knowledge of work of more than one kind, by answering a fair proportion of them, the rest of his paper will not be considered.

Moderately good drawing, showing an intelligent knowledge of the subject, will always be awarded higher credits at the examination than more highly finished drawings exhibiting an ignorance of constructive details.

FIRST STAGE, OR ELEMENTARY COURSE.

It is assumed that the student has already mastered the use of the following drawing instruments: rulers, ordinary and parallel; ruling pen; compasses, with pen and pencil bow-sweeps, as well as the construction and use of the simple scales, such as 1, 2, 3, or more feet to the inch, showing inches; or such as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{8}$, or other fraction of full size, or of any given scale or drawing: also the meaning of such terms as plan, elevation (front, back, or side), section, sectional elevation.

He should understand the object of bond in brickwork, *i.e.*, English bond, Flemish bond, or English bond with Flemish facing, and how it is attained in walls up to three bricks thick in the following instances, viz., footings with offsets, angles of buildings, connexion of external and internal walls, window and door openings with reveals and square jambs, external gauged arches (camber, segmental, and semi-circular), internal discharging arches over lintels, and inverted arches.

He should know where to put wood bricks, or plugging, and their use: the construction and uses of brick corbeling, and the construction of trimmer arches in fire-places.

He should be able to give sections and elevations to scale of the following kinds of mason's work, viz., uncoursed and coursed rubble, block in course, and ashlar, with their bond, and the proper dimensions of the stones, as to height, width of bed, and length; and of the following dressings, viz., window sills, window and door jambs, plain window and door heads, door steps, string courses, quoins, copings, common cornices, blocking courses; and of the following methods of connecting stones, viz., by cramps, dowels, joggels, and lead plugs.

He should be able to show how to join timbers by halving, lapping, notching, cogging, scarfing, fishing, and mortise and tenon; as applied to wall plates, roof timbers, floors, ceilings, and partitions.

He should be able to draw, from given dimensions, couple, collar, and king-post roofs, showing the details of the framing and of the ironwork.

He should be able to draw, from given dimensions, single, double, and framed floors, with or without ceilings beneath them; showing modes of supporting, stiffening, and framing the timbers, trimming round hearths and wells of stairs; also floor coverings of boards or battens, rebated and filleted, ploughed and tongued, and laid folding, with straight or broken joints, bevelled or square heading joints.

He should be able to draw in elevation, from given dimensions, a framed partition with door openings.

He should be able to draw in elevation, and give vertical and horizontal sections of solid door frames and window frames.

He should be able to describe, by drawings, beadings of different kinds, dovetailing, cross-grooving, rebating, plough-grooving, chamfering, rounded nosing, and housing.

He should be able to draw in elevation, and give vertical and horizontal sections of, the following doors, viz., ledged, ledged and braced, framed and braced, panelled, and the mode of putting them together, position of hinges and furniture ; as well as to describe, by drawing, the following terms as applied to panelled doors, viz., square and flat, bead butt, bead flush, moulded, all on one or both sides.

He should be able to draw in elevation, and to give vertical and horizontal sections of the following window sashes and frames, viz., single or double hung sashes with square, bevelled, or moulded bars, and cased frames ; casement sashes hung to solid frames, with method of hanging and securing in each case.

He should be able to show, in elevation and section, the leadwork connected with chimneys, ridges, hips, valleys, gutters, and lead-flats.

He should be able to give an elevation and section of the slating of a roof laid with Duchess or Countess slates on boards or battens.

He should be acquainted with the proper cross section for cast-iron beams for use in floor girders or bressummers, or as cantilevers ; and be able to draw such a section in its right proportions from given dimensions of flanges.

He should be able to draw in elevation, from given dimensions and skeleton diagrams, ordinary iron roofs up to 40 feet span, showing the sections of different parts, and methods of connecting them.

SECOND STAGE, OR ADVANCED COURSE.

In addition to the subjects enumerated for the Elementary Course—in all of which questions of a more complicated nature may be set, combining work done by the different trades—the knowledge of the students will be tested under the following heads, viz. :—

1st. Freehand sketches explanatory of any details of construction, such as the joints of iron and wooden structures, and other parts requiring illustration on an enlarged scale. These sketches may be roughly drawn, provided they are clear and capable of being readily understood.

2nd. The nature of the stresses to which the different parts of simple structures are subjected, as follows :—

In the case of beams either fixed at one or both ends, or supported or continuous, the student should know which parts of the beam are in compression, and which in tension.

He should be acquainted with the best forms for struts, ties, and beams, such as floor joists, exposed to transverse stress.

He should know the difference in the strength of a girder carrying a given load at its centre, or uniformly distributed.

In the ordinary kinds of wooden or iron roof trusses, and framed structures of a similar description, he should be able to distinguish members in compression from those in tension.

He should be able, in the case of a concentrated or uniform load or any part of a beam supported at both ends, to ascertain the proportion of the load transmitted to each point of support.

3rd. The nature, application, and characteristic peculiarities of the following materials in ordinary use for building purposes, viz. :—

Bricks of different kinds in common use, York, Portland Caen, and Bath stones (or stones of a similar description), granite, pure lime, hydraulic lime, Portland and Roman cement mortars, concretes, grout, asphalte, timber of different kinds in common use, cast and wrought iron, lead.

4th. Constructive details, as follows :—

The ordinary methods of timbering excavations, such as for foundations to walls, or for laying down sewers ; the erection of bricklayer's and mason's scaffolding ; the construction of travellers ; the use of piles in foundations, hoop-iron bond in brickwork, diagonal and herring-bone courses in ditto, damp-proof courses, bond timber in walls and the objections to it.

He should know how bricks are laid in hollow walls, window or door openings with splayed jambs, flues, chimneys, fireplaces, and arches up to about 20 feet span ; how mortar joints are finished off, and the thickness usually allowed to them ; why bricks and stones ought to be wetted before being laid.

He should be acquainted with the construction of brick ashlar walls, rubble ashlar walls, stone stairs, wooden stairs (both dog-legged and open newel), skylights, fire-proof floors (such as brick arches supported on rolled or cast-iron girders, Fox and Barrett's, and Dennett's patent concrete floors), circular and egg-shaped drains, roofs of iron or wood, for spans up to 60 feet; the fixing of architraves, linings and skirtings to walls, shutters to windows, lath, plaster, and battening to walls, roof coverings of tiles and zinc, slate ridges and hips.

Written answers will be required to some of the questions.

Examination for Honours.

The candidates will be called upon to answer in writing—illustrated by sketches, either freehand or to scale, as directed—questions on all the subjects previously enumerated for the elementary and advanced courses.

He must possess a more complete knowledge of building materials, their application, strength, and how to judge of their quality; and in the case of iron, of the process of manufacture, and the points to be attended to in order to ensure sound castings, and good rivetting.

He must be able to solve simple problems in the theory of construction, and to determine the safe dimensions of iron or wooden beams subjected to dead loads.

In ordinary roof trusses, and framed structures of a similar description. he must be able to trace the stresses, brought into action by the loads, from the points of application to the points of support, as well as to determine the nature and amount of the stresses on the different members of the truss, and, consequently, the quantity of material required in each part.

In ordinary walls and retaining walls, he must be able to ascertain the conditions necessary to stability, neglecting the strength of the mortar.

Those candidates who answer the questions in the written paper in a sufficiently satisfactory way will be permitted to enter for a practical examination which will be held at South Kensington.

This examination will be held in one day. The time allowed for work will be 7 hours—three hours in the morning and four hours in the afternoon. Candidates will be required to design some small building or portion of a building, giving a plan, section, and elevation. No candidate can be classed in Honours who is not successful in the practical examination.

When candidates are directed to attend the examination they will be made acquainted with the nature of the building they will be called upon to design.

Candidates must themselves provide drawing instruments, T-squares, and all other necessaries, except drawing paper and drawing boards, which will be supplied by the Department.

EXAMINATION PAPERS

OF THE

SCIENCE & ART DEPARTMENT, SOUTH KENSINGTON.

SUBJECT III.—BUILDING CONSTRUCTION.

Examiner, COLONEL SEDDON, R.E. (Ret.)

GENERAL INSTRUCTIONS.

If the Rules are not attended to, the paper will be cancelled.

You may take the Elementary, or the Advanced, or the Honours paper, but you must confine yourself to one of them.

Your name is not given to the Examiner, and you are forbidden to write to him about your answers.

All figures must be drawn on the single sheet of paper supplied, for no second sheet will be allowed.

All drawings must show a correct knowledge of construction. Neat and accurate drawing to scale is required. Where only sketches are asked for, the proportions must be approximately correct, though extreme accuracy, as in drawings to scale, is not necessary. The drawings may be left in pencil, provided they are distinct and neat. No extra marks will be allowed for inking in.

You are to confine your answers *strictly* to the questions proposed.

Put the number of the question before your answer.

Answers in writing must be as short and clearly stated as possible, and close to any figures to which they may refer.

The value attached to each question is shown in brackets after the question. But a full and correct answer to an easy question will in all cases secure a larger number of marks than an incomplete or inexact answer to a more difficult one.

A single accent (′) signifies *feet*; a double accent (″) *inches.*

Questions marked (*) have accompanying diagrams.

The examination in this subject lasts for four hours.

MAY, 1881.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

---

*1. Elevation and section of part of a dwarf brick wall.

Draw the elevation to twice the scale, showing 4 courses of English bond at A, and 4 courses of Flemish bond at B. (11.)

*2. Vertical section of joint between two stones.

Draw, to a scale of $1\frac{1}{2}''$ to a foot, showing a metal cramp run with lead. (11.)

*3. Plan of timbers crossing one another.

Draw, to a scale of $\frac{1}{6}$, two sections through *a a*; the first to be marked A, showing a notched joint; and the second to be marked B, showing a cogged joint. (11.)

4. One of the flanges of a cast iron *cantilever* is $5'' \times 1\frac{1}{2}''$, and the other $2'' \times 1''$; its web is $9''$ deep, and varying from $1''$ to $1\frac{1}{2}''$ in thickness. Give a vertical cross section, $\frac{1}{4}$ full size. (11.)

*5. Cross section through floor joists.

Draw, to a scale of $\frac{1}{12}$, adding $1\frac{1}{2}''$ floor boards, plaster pugging, and a lath and plaster ceiling. (11.)

*6. Cross section of a common rubble wall with moulded brick coping.

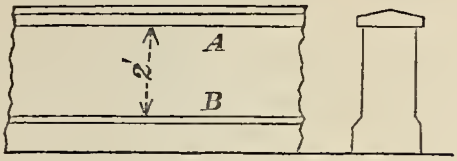
Draw, to a scale of $\frac{1}{24}$, showing the stones and 3 courses of tile creasing. (13.)

7. Draw, to a scale of 8′ to an inch, line diagrams of the following roof trusses .—

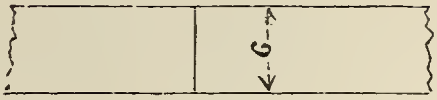
Collar beam truss for a 15 ft. span.
King-post truss for a 28 ft. span.

The names to be written on the different members.

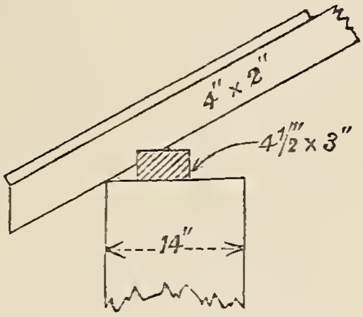
(13.)



*1.



*2.



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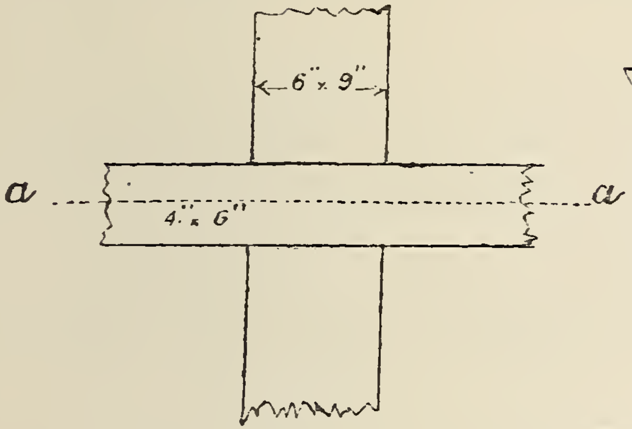
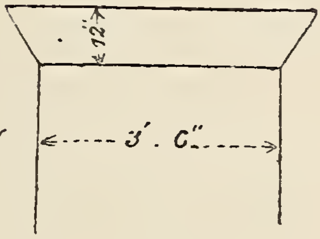
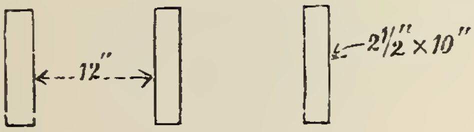


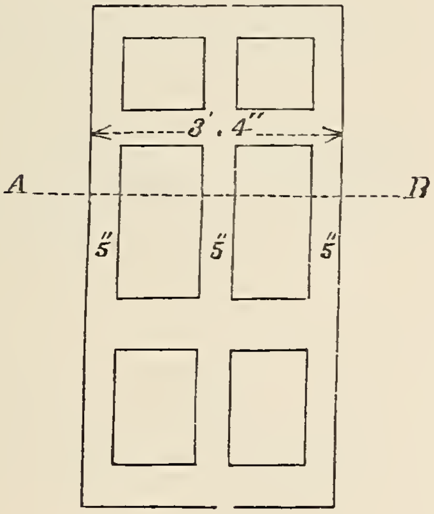
*3.



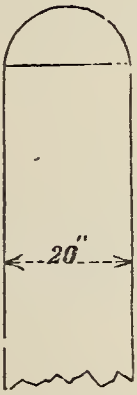
*11.



*5.



*12.



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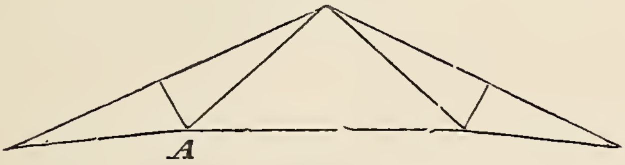


*13.

*8. Section of 9″ × $\frac{3}{4}$″ roof boarding on rafters.

Draw, to a scale of 1″ to a foot, adding Countess slates, laid to a 4″ lap, and centre nailed. (14.)

9. Give drawings, to a scale of $\frac{1}{12}$, explaining fully the following details :—

A butt joint, the timber being 9″ × 9″, and secured by $\frac{1}{2}$″ iron fish plates.

The foot of a 12″ × 12″ wooden story post mortised into a stone base 16″ × 16″ × 12″ ; the top of the base to be chamfered. (14.)

10. Give sketches showing the difference between a double floor with rolled girders, and a floor consisting of rolled girders, binders, and bridging joists. (14.)

*11. Elevation of the head of a door opening filled in with a common flat arch, used in inferior work, and known as a French or Dutch arch.

Draw, to a scale of $\frac{1}{12}$, showing by single lines the joints of the bricks forming the arch. (14.)

*12. Elevation of an outer door, 2$\frac{1}{2}$″ thick, framed and panelled, moulded outside and bead flush on inside.

Give a section through AB, to a scale of 1″ to a foot. (16.)

*13. A skeleton diagram of an iron roof truss for a 30 feet span.

Show what form of section you would adopt for each member ; and give a detail drawing, half full size, of the joint at A. (18.)

14. Give a vertical section, to a scale of $\frac{1}{6}$, through the sill of a double hung window sash, showing a stone sill, 11″ × 6″, resting on a 14″ brick wall, an oak sill 6″ × 3″, a 1$\frac{1}{2}$″ window board, and the bottom rail of a 2″ sash.

Also give a cross section through the meeting rails. (19.)

MAY, 1882.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. A and B are plans of two courses of bricks at the end of a wall.

Draw both courses, to the scale of $\frac{1}{12}$, altering A, if necessary, and showing on B the joints of the bricks by single lines.

Write against them the name of the bond. (11.)

*2. Cross section of a stone window sill in a 14″ brick wall.

Draw, to a scale of $1\frac{1}{2}''$ to 1′, showing it throated and grooved for a metal weather tongue; also show the joints of the bricks at A. (11.)

3. Give a cross section, half full size, of a rolled iron floor joist, $4\frac{1}{2}'' \times 9''$, with a $\frac{3}{8}''$ web and $\frac{3}{4}''$ flanges. (11.)

*4. Cross section of four battens $5'' \times 1\frac{1}{2}''$.

Draw, $\frac{1}{3}$ full size, showing a rebated and beaded joint at A, a ploughed and tongued joint at B, suitable for floor boards, and a rebated and filleted joint at C, for the same purpose. (11.)

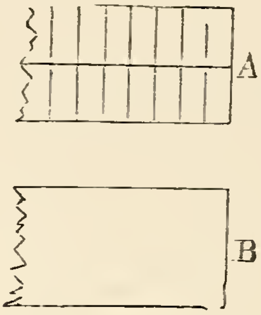
*5. Inside elevation of a small window opening.

Draw, to a scale of $1\frac{1}{2}''$ to 1′, showing a 3″ wood lintel with a common brick discharging arch above, in two rings. No joints to be shown except those of the arch. (11.)

*6. Elevation of the foot of a king-post at the centre of a tie-beam.

Give a section through AB, to a scale of $\frac{1}{12}$, showing all the details of a stirrup iron, with gibs and cotters. (13.)

7. Show, by means of a plan and section, the meaning of floor boards laid folding with broken joints. (13.)



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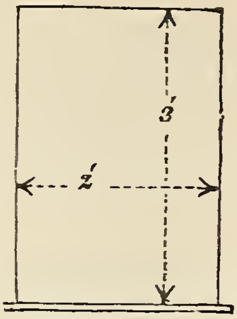

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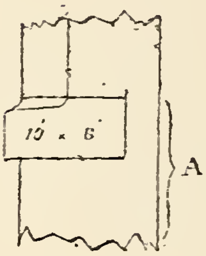

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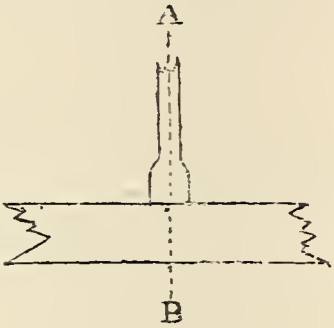

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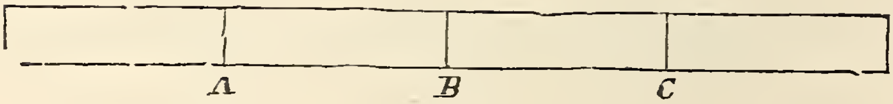

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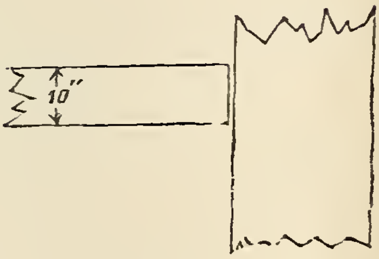

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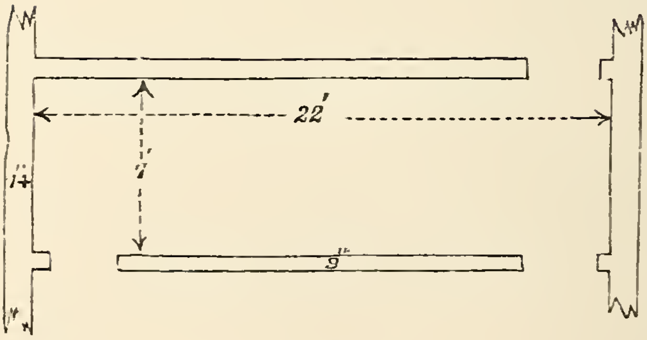

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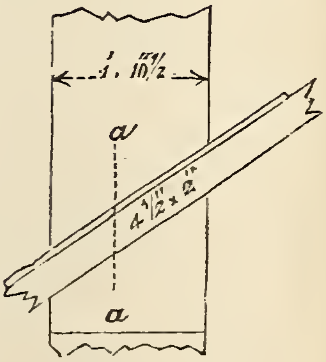


*14.

8. Show, by sections through the joint between two stones, the methods of connecting them together. 1st. By a lead plug; 2nd. By a metal cramp run with lead. (14.)

9. Give vertical sections, half full size. 1st. Through the bottom sash rail and the oak sill of a 1½″ double-hung window. 2nd. Through the meeting rails. (14.)

*10. Section through an 18″ brick wall, built in English bond, showing the end of a floor joist, which is to rest on a 4½″ × 3″ plate carried on brick corbelling.

Draw, to a scale of ¾″ to 1′, adding the wall plate and brick corbelling, and showing the joints of the bricks by single lines. (14.)

*11. Plan of a first floor passage.

Draw, to a scale of 4′ to an inch, showing the floor joists by single lines, with a well-hole 12′ × 3′ 6″ for the stairs.

Write their names against the different joists. (14.)

12. Give a vertical section, to a scale of $\frac{1}{12}$, through the panels of a 6′ 9″ door, framed as follows: 2″ deal, four panel, bead flush at bottom, moulded and flat at top, and square and flat at back. Top rail to be 5″, lock rail 10″, and bottom rail 9″. (16.)

13. Draw a horizontal section, half full size, through one side of a window frame for double-hung 1½″ moulded sashes; taking ⅝″ inside and outside linings, 1¼″ pulley piece, ⅜″ back lining, ⅜″ parting bead, 1″ × ⅝″ inside bead, ¼″ parting slip.

The sash stile to be shown in the section. (18.)

*14. Elevation of end of brick chimney shaft, with section through part of adjoining roof, showing slate, boarding, and rafter.

Draw, to a scale of 1½″ to 1′, adding 20″ Countess slates laid to a 3″ lap, with step flashings, &c., to keep out the weather. Give a section of the same through *aa*. (19.)

MAY, 1883.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Elevation of six courses at the end of a 14″ brick wall, built in Old English bond.

Draw to a scale of 1″ to a foot, making any alteration you may consider necessary. (11.)

*2. Vertical section through the centre of the upper portion of a stone pier.

Draw to a scale of $1\frac{1}{2}$″ to a foot, showing a stone cap 12″ deep at the centre, weathered and throated, and projecting 2″. (11.)

3. Draw to a scale of $\frac{1}{3}$ a cross section of—

A 3″ deal with one edge chamfered and one edge beaded.

A 2″ batten tongued and grooved. (11.)

*4. Section of an iron girder.

Draw half full size, stating against it whether it is intended for a cast or a wrought iron girder. Without altering the dimensions, make any improvement in the form you may think advisable. (11.)

*5. Joint at the head of a small wooden roof truss.

Draw to a scale of $\frac{1}{12}$, making any corrections you may consider necessary. Write its name against the truss, and against each of the members shown. (12.)

*6. Elevation of part of a dwarf wall, with stone coping.

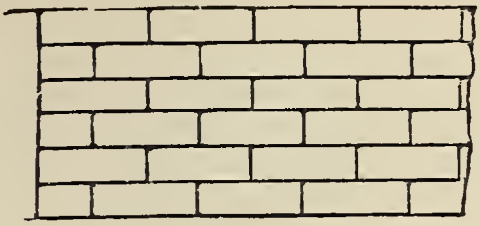
Draw to twice the scale, showing at A coursed rubble, and at B irregular coursed or snecked rubble. (12.)

7. Draw, to a scale of 8 feet to an inch, single line diagrams showing—

A king-post truss for a 25 feet span; rise to be $\frac{1}{4}$ span.

A queen-post truss for a 40 feet span; rise to be $\frac{1}{3}$ span.

Write the names of the different members. (13.)



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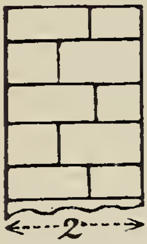

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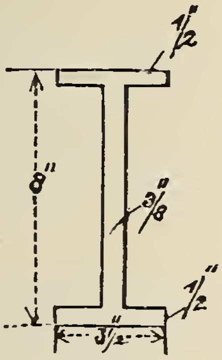

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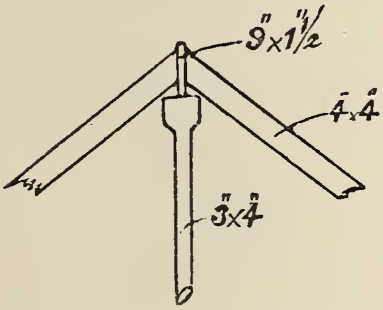

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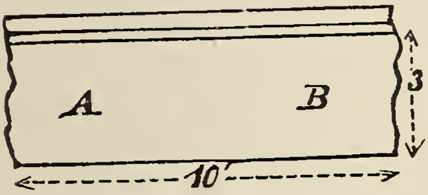

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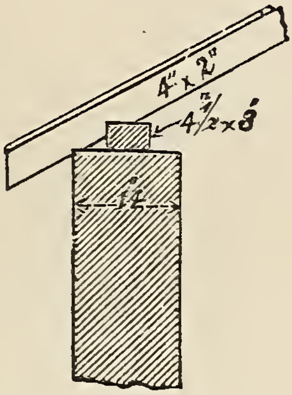

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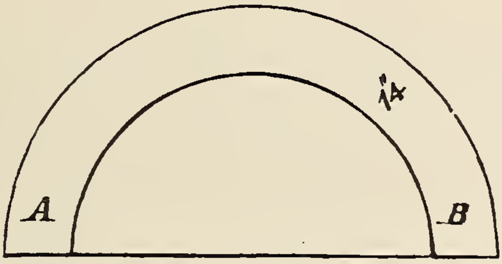

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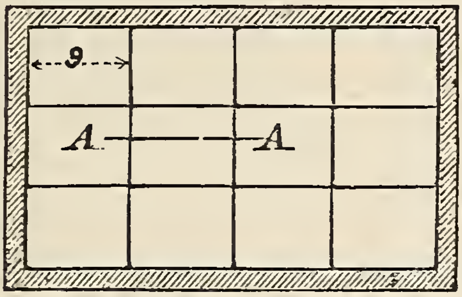

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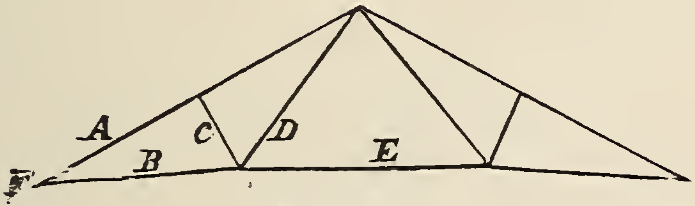


*14.

*8. Section through the eaves of a roof.

Draw, to a scale of $\frac{1}{12}$, adding three courses of slates, 20″ long, properly laid to a 4″ lap. Write their names against the different members. (13.)

*9. A semicircular opening in a brick wall.

Draw, to a scale of $1\frac{1}{2}$″ to a foot, showing—
At A, six courses of a plain or rough arch.
At B, four courses of an axed or rough cut arch.
(13.)

10. Give a vertical section, $\frac{1}{4}$ full size, through both the wood and the stone sills of a window opening for a $1\frac{1}{2}$″ swing sash. The stone sill to be 6″ × 4″, weathered and throated, and to rest on a 9″ brick wall. The wood sill to be 4″ × 3″, with a $1\frac{1}{4}$″ inside bead, and a $1\frac{1}{4}$″ window board. (15.)

11. A room, 14′ wide, is to be divided in two by a quarter partition. It is to rest on the $4\frac{1}{2}$″ × 3″ plates which carry the floor joists on brick offsets.

Give, to a scale 2′ to an inch, an elevation of the framing of the partition, showing a central opening 7′ × 3′ for a door.

The scantlings, which are to be marked on the different members, are to be as follows:—

Sills	4″ × 4″
Studs or quarters . .	4″ × 2″
Braces	4″ × 2″
Door studs	4″ × 3″

The details need not be filled in on both sides of the doorway. (15.)

12. Draw, to a scale of $\frac{1}{2}$″ to a foot, the back elevations of both a ledged door and a framed and braced door; to be 7′ × 3′, and put together in batten widths. (16)

*13. Plan of a floor in which the girders are rolled iron joists 10″ × $4\frac{1}{2}$″, and the binders of wood 9″ × 6″ resting on the top of the girders, and carrying 6″ × 3″ bridging joists, and $1\frac{1}{2}$″ floor boards, 7″ wide.

Give a section, to a scale of $\frac{1}{24}$, through AA, showing the construction. (18.)

*14. A line diagram of an iron roof truss for a 25′ span.

Show what forms of section you would adopt for each of the members, A, B, C, D, E. Assuming the dimensions of A and B, give a detail drawing $\frac{1}{3}$ full size, of the joint F, using a cast-iron shoe to form the connection.
(19.)

MAY, 1884.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Plan of a course of bricks at the end of a two-brick wall.

Draw, to a scale of $\frac{1}{12}$, the plan of the next course, and write against it the name of the bond. (11.)

*2. Longitudinal section through three coping stones.

Draw to a scale of 1½" to a foot, showing the joint A secured by a slate dowel, and B by a joggle. (11.)

*3. A is the plan and B the elevation of the end of a timber balk.

Show, at A, two such balks connected by ½" iron fish-plates, and at B by halving, to a scale of 1½" to a foot. (11.)

4. Give a vertical cross section, to a scale of $\frac{1}{6}$, through a cast-iron cantilever 9" deep, the flanges being respectively 4" × 1" and 2½" × ⅝", and the web varying from 1" to ⅝". (11.)

---

*5. Inside elevation of a window opening in a brick wall.

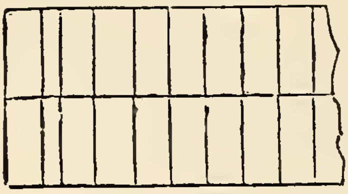
Draw the head of the window, to scale of 1½" to a foot, showing a wood lintel 4' long by 3" deep, with a discharging arch, in two rings, above it. The separate bricks of the arch rings need not be shown. (12.)

*6. Section of a coursed rubble wall faced with ashlar, with a through bondstone at A.

Draw it, to a scale of $\frac{1}{12}$, making any alteration you may deem necessary in the ashlars, and filling in the joints of the rubble work. (12.)

*7. Horizontal section through a door.

Draw to a scale of 1½" to a foot, showing the panel, at A, bead flush one side and square and flat at back, and, at B, filled in solid. (13.)



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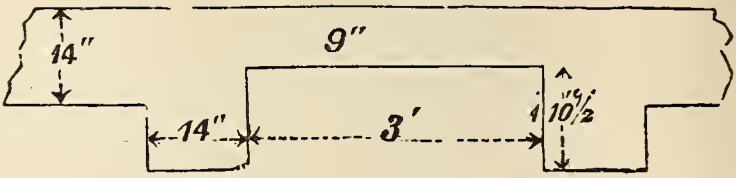

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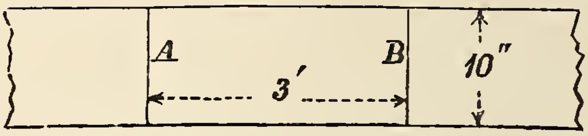

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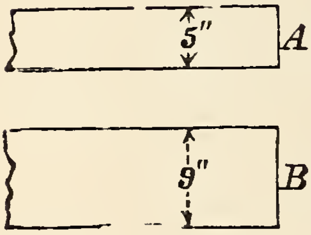

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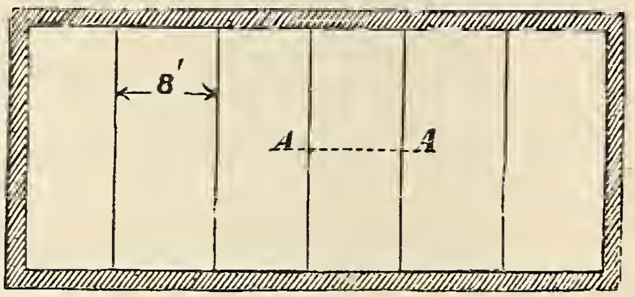

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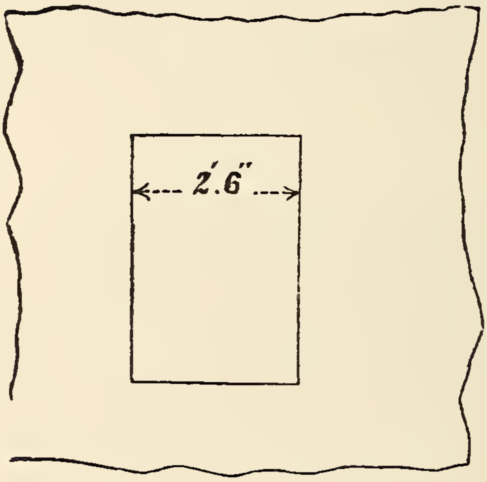

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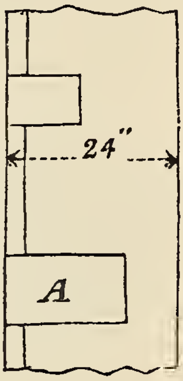

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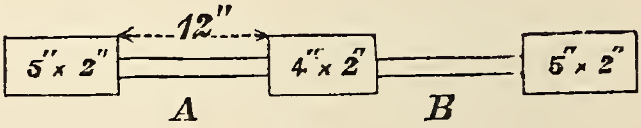


*7.

*8. Plan of a fireplace in the long side of a room.

Draw it to a scale of $\frac{1}{2}''$ to a foot, adding trimming joists $10'' \times 2\frac{1}{2}''$, trimmer $10'' \times 3''$, and trimmed joists $10'' \times 2''$

Figure the scantlings on the different joists. (13.)

9. Show by sketches the meaning of the terms, "fox-wedging" and "chase mortise." (13.)

10. Give a cross section of a $2''$ drip, in a lead gutter, half full size, showing $1''$ boards and $3'' \times 2''$ bearers. (15.)

11. Give, to a scale of $3'$ to an inch, an elevation of a collar beam roof truss, for a $12'$ span.

Show $4\frac{1}{2}'' \times 3''$ wall plates resting on $14''$ brick walls, rafters $5'' \times 3''$, collar $4'' \times 2''$ halfway up, ridge-piece $9'' \times 1\frac{1}{2}''$. (15.)

*12. Plan of a double floor showing position of girders.

Give a section through AA, to a scale of $\frac{3}{4}''$ to a foot, showing rolled iron girders $5'' \times 10''$, bridging joists $8'' \times 2\frac{1}{2}''$, floor battens $7'' \times 1\frac{1}{2}''$, and ceiling joists $4'' \times 2''$. (16.)

13. Draw a horizontal section, to a scale of $\frac{1}{6}$, through one jamb of a $3'$ doorway in a $14''$ brick wall, showing a $4\frac{1}{2}''$ reveal and the bricks laid in Flemish bond, a solid frame $5'' \times 4\frac{1}{2}''$, rebated and chamfered, and about half the door, which is to be framed and braced, with $5'' \times 2''$ hanging style and $4\frac{1}{2}'' \times \frac{3}{4}''$ battens. (18.)

14. Give an elevation, to a scale of $2'$ to an inch, of a little more than half of a king-post roof truss, resting on $14''$ brick walls, 20 feet apart, taking the following scantlings:—

Wall plates - - -	$4\frac{1}{2}'' \times 3''$
Tie-beam - - - -	$9'' \times 3''$
Principals - - - -	$6'' \times 3''$
Struts - - - -	$3'' \times 3''$
King-post - - - -	$4'' \times 3''$

Heelstraps and stirrup iron $2''$ wide. (19.)

MAY, 1885.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Elevation of part of the end of a brick wall built in Flemish bond.

Draw, to a scale of 1½″ to a foot, showing the bricks in the courses marked *a*. (11.)

*2. Elevation of part of a stone wall built of squared rubble, built up to courses.

Draw, to a scale of 2′ to an inch, showing the arrangement of the stones. (11.)

*3. Joint between the foot of a principal rafter and the tie-beam of a wooden roof truss, showing the end of the tie-beam resting on a brick wall.

Draw, to a scale of 2′ to an inch, making any alterations you consider necessary, and adding a heelstrap 2′ wide. (11.)

*4. Single line section of a cast-iron girder which is to be supported at both ends and loaded at the centre.

Draw, to a scale of 2″ to 1′, making the top flange 1″ thick, the bottom flange 1½″ and the web averaging 1¼″. (11.)

---

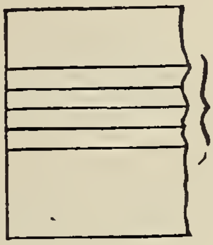
*5. Elevations of a stone arch.

Draw to twice the scale, writing against them the names of the following parts :—The lines AaA, BbB, and AB ; a single stone of the arch, as C ; the highest stone, D, of the arch ; the spaces, E, over the arch. (12.)

6. Draw, to a scale of 3′ to 1″, a cross section through a couple roof, resting on 9″ brick walls 12′ apart. Rafters and wall plates to be 4″ × 2″, ridge board 7″ × 1½″. Only the four top courses of the walls to be shown, with the eaves projecting 9″. (12.)

*7. Side view of a stone corbel to carry a girder.

Draw, to a scale of $\frac{1}{12}$, a section of about 10 courses of an 18″ brick wall, showing the bricks and the corbel in position. (13.)



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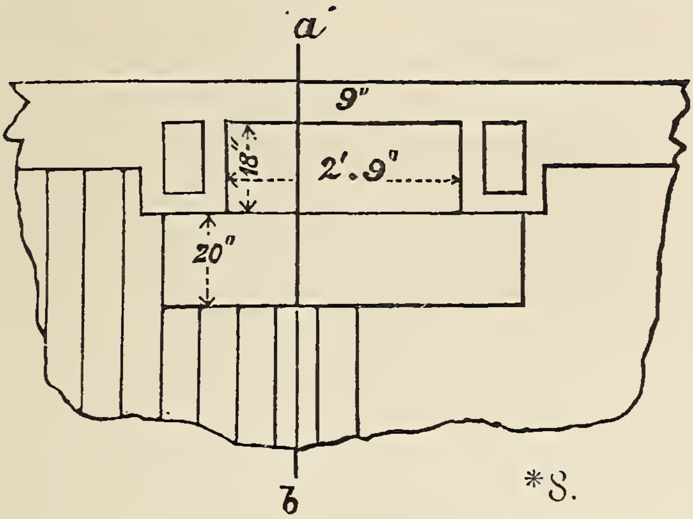

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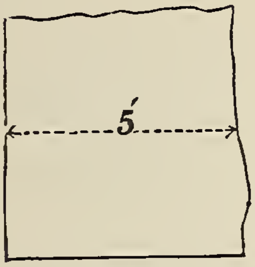

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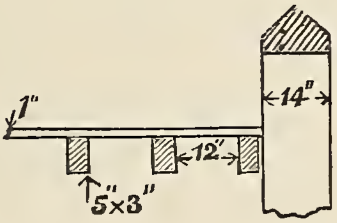

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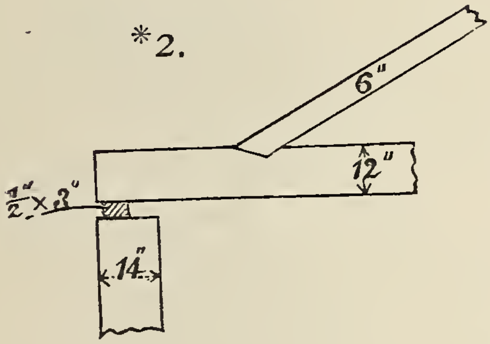

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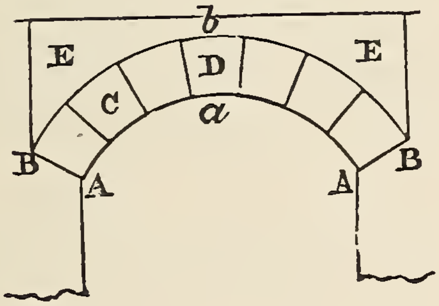

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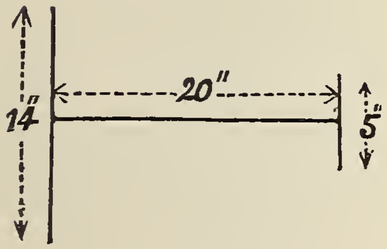

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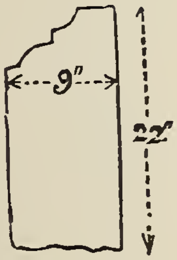

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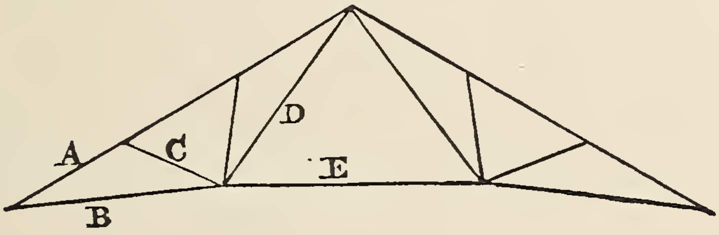


*14

*8. Plan of part of the floor of an upper room, showing a fireplace.

Draw, to a scale of $\frac{3}{4}''$ to a foot, a vertical section through *ab*, showing a trimming joist 9″ × 3″, common joists 9″ × 2″, floor boards $1\frac{1}{2}''$, front hearth 3″, back hearth 2″, and a half brick trimmer arch. (13.)

9. Show by sketches the meaning of the following terms :—

Match boarding ;
Mortise and tenon ;
Haunched tenon.

State the object of the latter. (13.)

*10. Section through the gable end of a slate roof, showing a brick parapet with stone coping, common rafters and slate boarding.

Draw to a scale of $\frac{1}{12}$, adding Countess slates, and lead flashing, to keep the weather out. (15.)

11. Give an elevation, to a scale of 2′ to 1″, of little more than half of a naked wooden trussed partition, 10′ high and 15′ long, with a 7′ × 3′ central opening, from the following details :—Sills 4″ × 5″, and resting 6″ on 3″ stone templates in 14″ brick walls ; door studs 4″ × 4″ ; all other scantlings 4″ × 2″. (15.)

12. Draw, to a scale of 6′ to an inch, a single line diagram showing the form of a king-post roof truss for a 30′ span, the rise being $\frac{1}{4}$ the span.

Write their names on the different members, and draw $\frac{1}{6}$ full size, an elevation of the joint at the top of the truss, the members consisting of a cast iron head, 5″ × 5″ timbers, and an iron rod $1\frac{1}{4}''$ diameter. (16.)

13. Give, to a scale $\frac{1}{3}$ full size, a horizontal section through one side of a window opening in a 14″ brick wall, showing all the details connected with a wooden cased frame for 2″ double hung sashes, with half brick reveals and plastered jambs. The joints of the brickwork need not be shown.

The following dimensions to be adopted :—1″ inside lining, $1\frac{1}{4}''$ pulley style and outside lining, $\frac{3}{8}''$ parting bead, $\frac{1}{2}''$ back lining and parting slip, $1\frac{1}{2}'' \times \frac{3}{4}''$ inside bead. A sash style to be shown. (18.)

*14. A line diagram of an iron roof truss for a 35′ span.

Show by sketches the form of section you would adopt for each of the members marked A, B, C, D, E.

Assuming the dimensions of A and B, give a drawing, $\frac{1}{3}$ full size, of the joint connecting them, showing a cast-iron shoe, and some means of tightening up B. (19.)

MAY, 1886.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Segmental gauged arch over an opening in a brick wall.

Draw, to a scale of $\frac{1}{12}$, showing at A six courses of the arch bricks, starting from the springing. (11.)

*2. Section of a coursed rubble dwarf wall.

Draw, to a scale of $1\frac{1}{2}''$ to a foot, showing the construction, and adding a 6″ stone coping weathered and throated. (11)

*3. Sections of the flanges and web of a cast-iron cantilever.

Draw the section of the cantilever $\frac{1}{3}$ full size. (11.)

*4. Head of a king-post in a wooden roof truss.

Draw, to a scale of $\frac{1}{8}$, adding the heads of the principals 6″ × 4″, and a ridge board 11″ × 2″, and making any alteration you think necessary. (11.)

---

*5. Elevation of a window opening with a stone lintel, the depth of which is equal to four courses of bricks.

Draw, to a scale of $\frac{3}{4}$ of an inch to a foot, a vertical section through AA, the wall being 18″ thick, with a 9″ × 3″ wood lintel, and a discharging arch of two half brick rings. (12.)

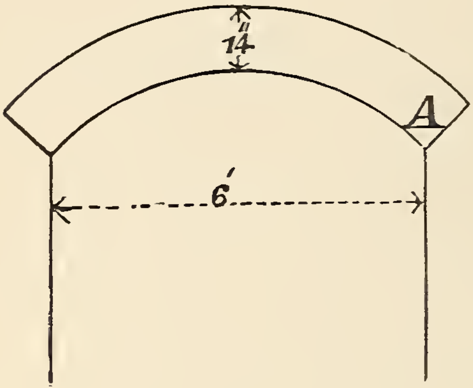
*6. Cross section of a beam and iron flitch, which are to be formed into a flitch girder.

Draw the section of the girder to a scale of $\frac{1}{12}$, showing $\frac{3}{4}''$ bolts by dotted lines. (12.)

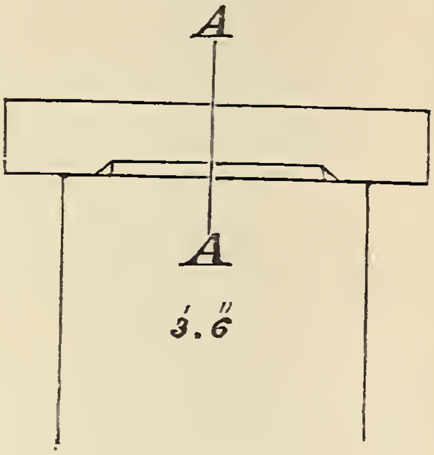
7. Show by sketches the meaning of the following terms in carpenters' work :—

Birdsmouth—mortised and housed—dovetail-halving. (13.)

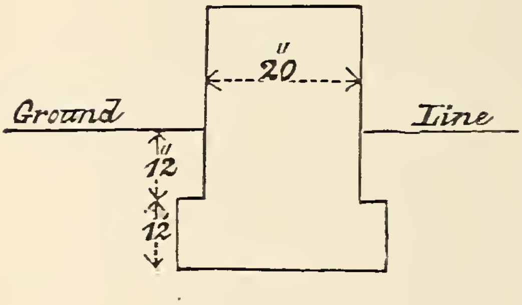
8. Draw a cross section, to a scale of $\frac{1}{2}''$ to a foot, showing a 9″ sleeper wall supporting a single joist floor. (13.)


14"
A
6'

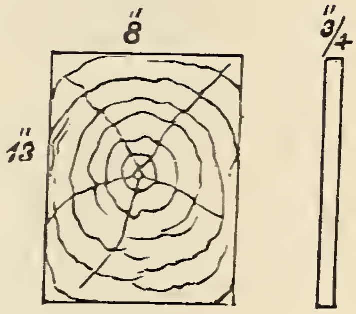
*1.


A
A
3'.6"

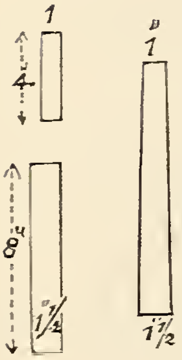
*5.


20"
Ground
Line
12"
12"

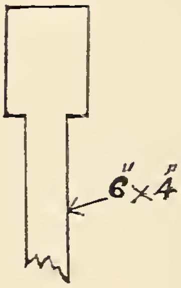
*2.


8"
3/4"
13"

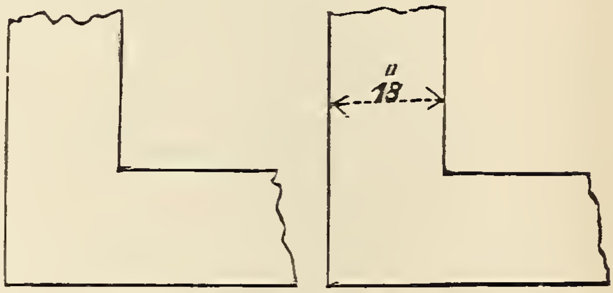
*6.


1
4
8"
1½"
1"
10"
1½"

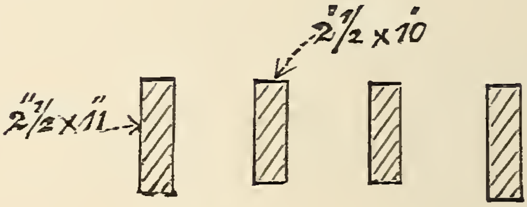
*3.


6"×4"

*4.


18"

*9.


2½"×10"
2½"×11"

*10.

*9. Plan of two successive courses of brickwork at the angle of a building.

Draw, to a scale of $\frac{3}{4}''$ to a foot, showing the bricks laid in English bond. (13.)

*10. Cross section through four common joists, 15″ from centre to centre.

Draw, to a scale of $\frac{1}{12}$, adding $1\frac{1}{2}''$ floor boards and 3″ × 2″ ceiling joists, also sound boarding and pugging. (15.)

11. Draw a horizontal section through a $2\frac{1}{2}''$ framed and panelled door, to a scale of $\frac{1}{4}$.

The door to be 3′ 6″ wide, with 5″ margins, one panel to be square and flat and moulded one side, and the other to be bead butt both sides. (15.)

12. Draw, to a scale of 3′ to an inch, an elevation of a little more than half of a queen-post roof truss for a 35′ span from the following details :—

Tie-beam - - - - -	5″ × 9″
Principals - - - - -	5″ × 6″
Queens - - - - -	5″ × 3″
Straining beam - - - -	5″ × 8″

Stirrup irons and heel straps to be 2″ × $\frac{1}{4}''$. (16.)

13. Give a horizontal section, to a scale of $\frac{1}{6}$, through a little more than half of a French casement window, 3′ 6′ wide, in an 18″ wall, showing folding sashes opening outwards.

The inside of the frame to be flush with the inside of the wall, and the joint between the frame and wall to be covered with a plain chamfered architrave.

Give a freehand section of the bottom rail and sill, showing how you would keep out the weather. (18.)

14. The cast iron columns supporting a floor are of 1″ metal 7″ mean outside diameter, and 10′ long.

Rolled iron joists, 12″ × 5″, meeting at right angles on the heads of the columns, carry a flat concrete floor 7″ thick.

Give a sectional elevation, to a scale of an inch to a foot, through the concrete and one of the joists, showing the connection of the cross girders on the head of the column. (18.)

MAY, 1887.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

*1. Plans of two successive courses of a brick wall built in single Flemish bond.

Draw, to a scale of $\frac{1}{12}$, showing the arrangement of the bricks. (11.)

*2. Elevation of part of the end of a stone wall.

Draw, to a scale of 2′ to an inch, showing at A squared rubble built up to courses, and at B block-in-course work, with plain ashlar quoins to both. (11.)

*3. Plan of the joint between a trimmer and a trimming joist.

Give a vertical section through A—A, to a scale of $\frac{1}{5}$, and show which is the trimmer. (11.)

*4. Cross section through a roof gutter behind a brick parapet.

Draw, to a scale of $\frac{3}{4}''$ to a foot, adding the bricks, slate boarding and tilting fillet, lead gutter and flashing. (11.)

5. Give sketches explaining the following terms in carpenters' work:—

Plain fished joint—cogged joint—stump tenon. (12.)

*6. Vertical section through the footings of an external wall of a brick dwelling-house, the brickwork resting on the soil.

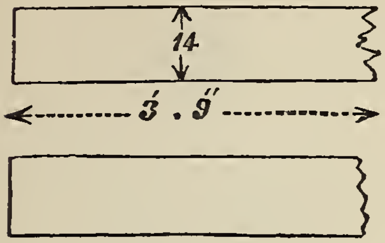
Draw, to a scale of $\frac{1}{2}''$ to a foot, making any alteration to the footings you think necessary, and showing the bricks laid in English bond. Nothing but brickwork to be shown. (12.)

*7. Line diagram of an iron roof truss.

Give, to a scale of $\frac{1}{3}$, a detailed drawing of the joint at A, the struts being of angle iron, 3″ × 3″ × $\frac{5}{8}''$, the tie-rod 1″ diameter, and the king-rod $\frac{3}{4}''$ diameter. (12.)

*8. Section through the eaves of a roof.

Draw, to a scale of 1″ to a foot, adding 1″ slate boarding covered with Countess slates, 20″ × 10″, laid to a 3″ lap and centre nailed. The slating to show 4 margins. The thickness of the slates may be exaggerated to show the details distinctly. (13.)



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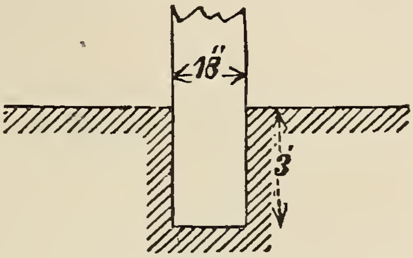

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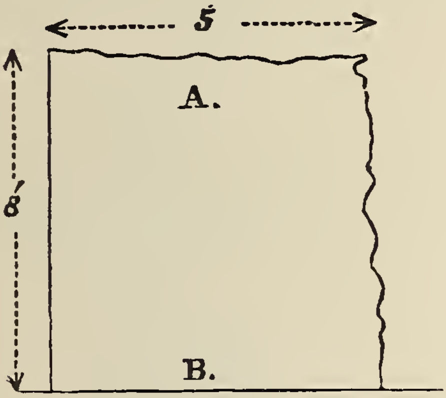

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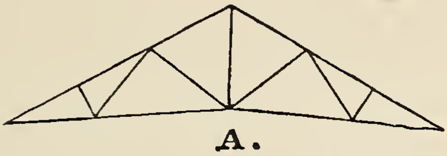

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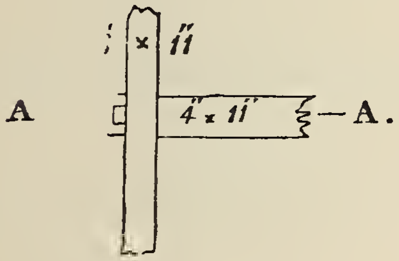

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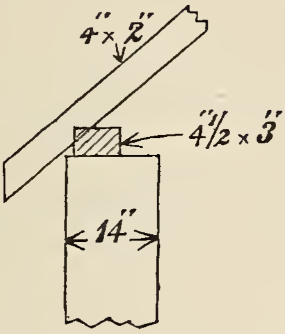

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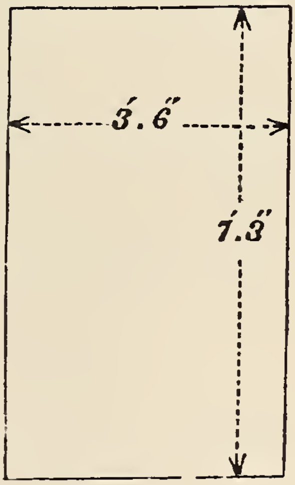

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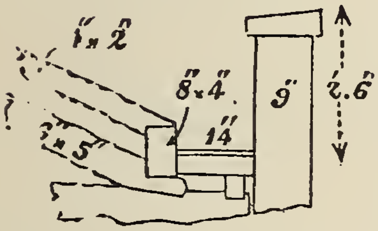

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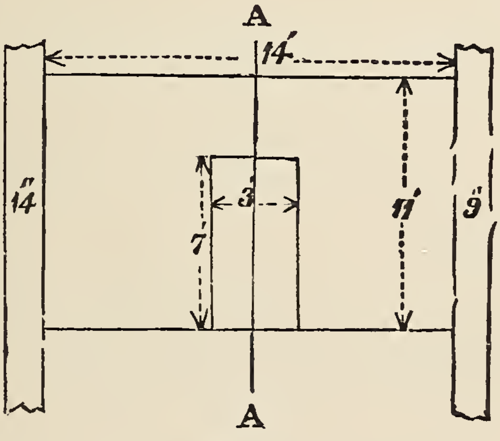


*11.

9. Show, by a section ½ full size, how an iron bar, 1¼″ diameter, would be leaded into a block of stone.

Give sketches showing the difference between a joggle and a dowelled joint in masonry. (13.)

10. Draw, to a scale of 1″ to a foot, the end of a floor joist 9″ deep, notched on to a 4″ × 3″ wall plate carried on brick corbeling, the wall being 14″ thick. The section of the wall to show the method of corbeling out the bricks. (13.)

*11. Elevation of a trussed partition between two rooms.

Draw, to a scale of $\frac{1}{24}$, the portion to the left of the line A—A, showing the following details, and how it is supported, as well as any ironwork you may consider necessary :—

Head - - - - -	4½″ × 6″	
Sill - - - - -	4½″ × 4″	
Quarter or studs - - -	4½″ × 2″	
Door studs - - - -	4½″ × 4″	
Braces - - - - -	4½″ × 3″	
Nogging pieces (one row) -	4½″ × 2″	(14.)

12. Give, to a scale of ¾″ to a foot, sections, at right angles to the direction of the floor boards, showing the difference between a double and a framed floor.

The double floor to be finished with 1½″ rebated boards, and the framed floors with 1½″ battens, rebated and filleted.

Their names to be written against the different members. (15.)

13. Draw, to a scale of ¼, a horizontal section through a window jamb in a 14″ wall, showing the details of a cased frame for 2″ double hung, moulded, sashes.

Give the section of a sash style, and write their names and dimensions against the different members of the frame. (16.)

*14. Front elevation of a framed and braced door with 6″ styles, 7″ top rail, 9″ bottom rail, 10″ lock rail, and 6″ braces, and filled in with 5″ battens.

Draw, to a scale of $\frac{1}{18}$, showing by dotted lines the members at the back of the door. (16)

MAY, 1888.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Cross section of a stone to be formed into a window sill.

Draw, to a scale of $\frac{1}{4}$, the finished cross section, at the centre, showing it weathered, throated, and grooved for a metal tongue. (11.)

*2. Cross section of six courses of a $2\frac{1}{2}$ brick wall built in English bond.

Draw, to a scale of an inch to a foot, making any alteration you may think necessary. (11)

*3. A and B are sections through a wooden floor girder and a bridging joist.

Draw, to a scale of $\frac{1}{5}$, two cross sections of the girder, showing the joist notched to it in the one case, and cogged to it in the other.

The cogged joint to be marked C, and the notched joint N. (11.)

*4. A is the section of a stone string course. B is a part cross section of a coursed rubble wall built of a thin bedded stone occurring in layers of from 4″ to 8″ thick.

Draw B, to a scale of $1\frac{1}{4}''$ to a foot, showing the stones, and inserting the string course at *a*. (11.)

5. Explain by sketches the following terms :—

Return or staff bead.
Rebated and beaded boards for partition.
Shouldered or tusk tenon. (11.)

*6. Elevation of a 9″ arch ring, over an opening in a brick wall built in Flemish bond. Span of arch 6′, and rise 12″.

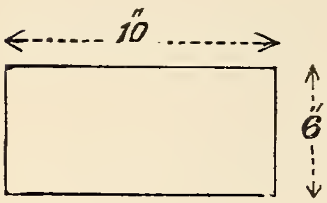
Draw, to a scale of $\frac{3}{4}''$ to a foot, showing 4 courses of the arch bricks at A, and 4 courses of the wall bricks at B. (12.)

*7. Drawing of a stone template to carry the end of a cast-iron girder 10″ deep, with flanges $1\frac{1}{4}'' \times 8''$ and $\frac{3}{4}'' \times 3''$.

Draw the girder, $\frac{1}{3}$ full size, in cross section, showing the template in elevation. (12.)

8. Draw, to a scale of $\frac{1}{48}$, line diagrams showing the difference between a wooden king-post and queen-post roof-truss ; one for a span of 36′, and the other for a 24′ span.

Write their names against the different members. (13.)



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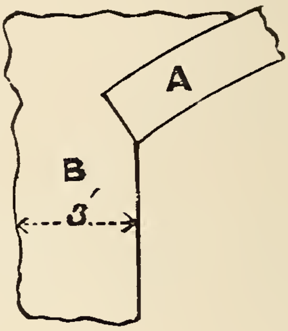

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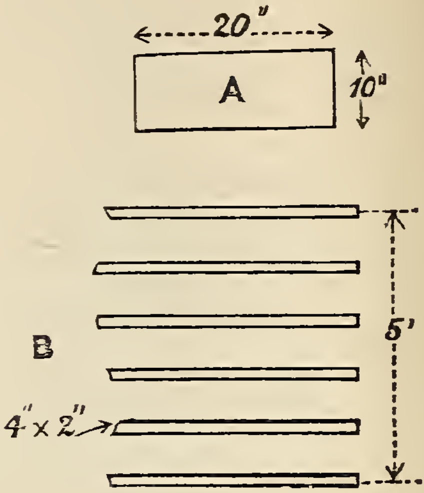

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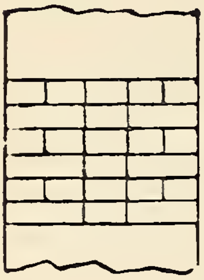

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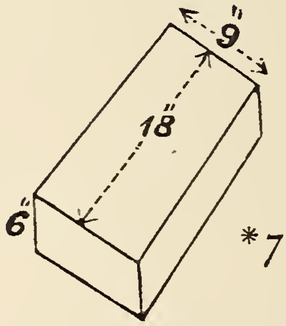

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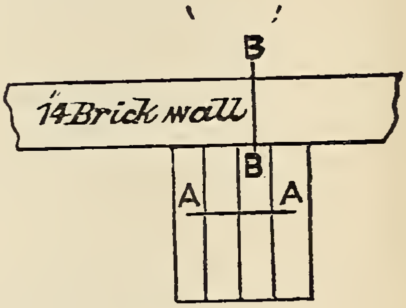

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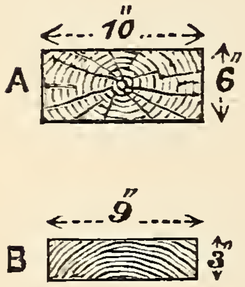

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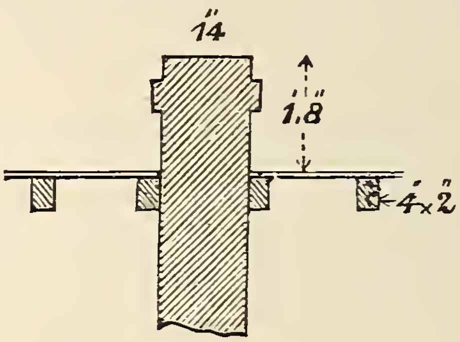

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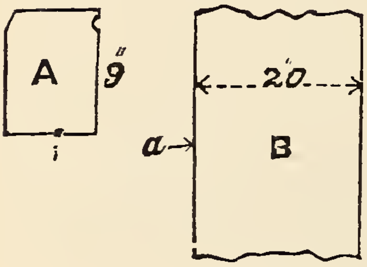

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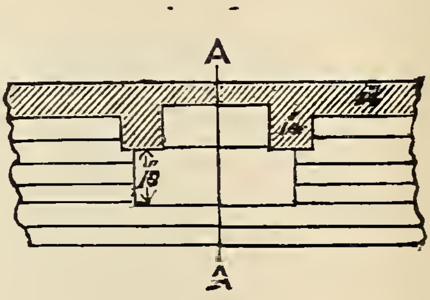


*13.

*9. Section through a portion of a slate roof divided by a party wall.

Draw to a scale of $\frac{1}{12}$, showing the slates, with two different methods of using lead to form a watertight joint between them and the wall.

The thickness of the slates should be exaggerated, and the section should pass through a lap. (13.)

*10. A is a plan of a roofing slate.

By what name is this sized slate known?

B is a plan of the ends of 6 common rafters at the eaves of a roof.

Draw B, to a scale of $\frac{1}{2}''$ to a foot, adding 9″ slate boarding, a tilting fillet, and slates, as A, laid to a 4″ lap.

Put 5 slates in width in the doubling eaves course, and one less in each of the four following courses.

The nail holes where exposed to show centre nailing. (13.)

11. Draw to a scale of $\frac{1}{12}$, a vertical cross section through the joint between the king-post and the tie-beam, the latter being 11″ × 6″ in a timber roof truss.

Show the full details of the stirrup, etc., before tightening up. (14.)

*12. Plan of part of a stone stair.

Draw, to a scale of $\frac{3}{4}''$ to a foot, a section through A—A, showing square steps with rebated joints, a 6″ rise and moulded nosings.

Also a section through B—B. (15.)

*13. Plan of part of a first-floor room in a dwelling-house, the boards being carried on common joists 10″ × 2½″, trimming joists and trimmers 10″ × 3″.

Give, to a scale of $\frac{1}{2}''$ to a foot, a vertical section through A—A, showing a brick trimmer arch and a lath and plaster ceiling below. (16.)

14. Give, to a scale of $\frac{1}{5}$, a horizontal section through one jamb of an entrance doorway to a dwelling-house, the outer walls being 18″ brickwork with chamfered stone quoins to openings.

The following to be shown:—

Inner face of wall plastered flush with door frame.
Single architrave to door frame.
Hanging style of door 6″ × 2½″.
Panel (part only) bead flush and moulded at back.

(16.)

MAY, 1889.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plan of the angle of a brick building built in English bond.

Draw, to a scale of ½″ to a foot, showing the joints of the bricks by single lines. (11.)

*2. Sketch, showing the end of a beam to be connected with a similar one by an ordinary scarfed joint.

Give a plan and elevation of the joint to a scale of 1″ to a foot. (11.)

3. Explain, by sketches or otherwise, the following terms :—edges shot—ploughed, tongued and V jointed—mortised and housed. (11.)

*4. Section of a stone wall built of coursed, flat bedded, rubble.

Draw, to a scale of ¾″ to a foot, showing the stones in the wall, including two ¾ bond stones, and adding a flushed stone coping, weathered at top. (11.)

*5. Vertical cross section through the joints of a stone landing.

Draw, to a scale of $\frac{1}{12}$, showing at A a rebated joint, and at B a joggled joint. (11.)

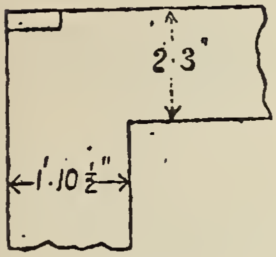
*6. Single line section of a cast-iron girder, 10″ × 4″ × 15″ deep.

Taking the thickness of the top and bottom flanges at 1½″ and 1″ respectively, draw its section, ¼ full size, and state how such a girder ought to be used. (12.)

7. Draw, to a scale of ¼, cross sections of the joints you would use in the lead gutter of a roof to connect the ends of the sheets together. (12.)

*8. Elevation of the back of a framed and braced door.

Draw, to a scale of ¾″ to a foot, making any alteration you think advisable, and filling in with rebated and beaded battens. Only the joints in connection with the hanging tile to be dotted in. (13.)



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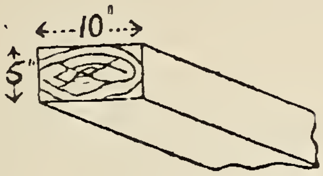

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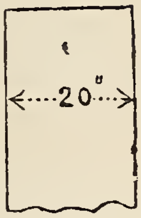

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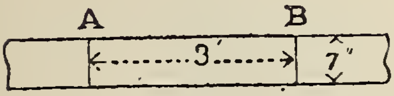

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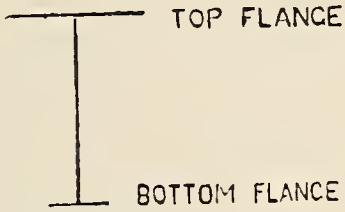

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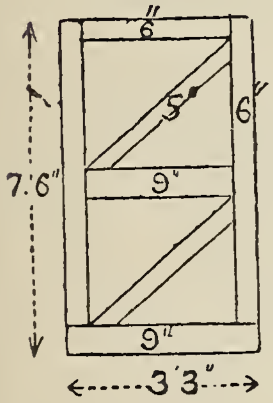

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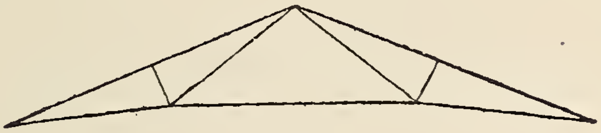

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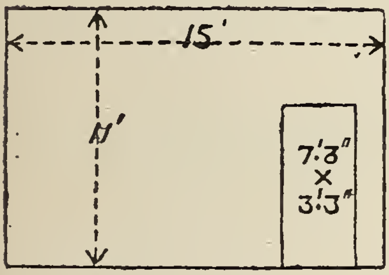

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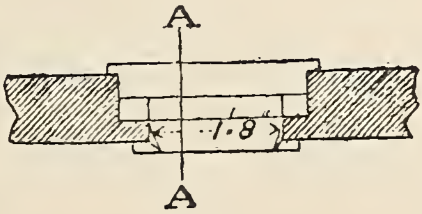

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9. Give, to a scale of $\frac{3}{4}''$ to a foot, sections across a few floor boards, showing the construction of:—

A single floor with $1\frac{1}{2}''$ boards, rebated and filleted.
A double floor with $1\frac{1}{2}''$ boards, grooved and tongued.
13.)

*10. Line diagram of an iron roof truss.

Draw, $\frac{1}{3}$ full size, an elevation of the joint at the head of the truss, the members consisting of **T** irons, $2\frac{3}{4}'' \times 2\frac{1}{2}'' \times 1\frac{1}{2}''$, and two bars $2\frac{1}{4}'' \times \frac{1}{4}''$. (13.)

11. Draw, to a scale of 3′ to an inch, a cross section through a wooden roof over a 16′ span, showing:—

Rafters - - - -	$4'' \times 2''$
Collar - - - -	$4\frac{1}{2}'' \times 2''$ half way up
Ridge Piece - - -	$7'' \times 1\frac{1}{2}''$
Wall Plates - - -	$4'' \times 2''$
Brick Walls - - -	$14''$.

The rise to be $\frac{1}{3}$ span, and the rafters not to be weakened in connecting the collar to them. (14.)

12. Draw to a scale of $\frac{1}{5}$, a cross section through a lead gutter at the back of a chimney shaft, showing all the details of construction, the rafters being $4'' \times 2''$, carrying Countess slates (3 courses to be shown) on $\frac{3}{4}''$ boards. (15.)

*13. Elevation of a $4\frac{1}{2}''$ trussed partition, to be constructed out of $9'' \times 3''$ and $9'' \times 2''$ deals.

Give its elevation, to a scale of 3′ to an inch, writing against them the names and scantlings of the different members. (16.)

*14. Horizontal section through a window, 1′ 8″ × 2′ 6″ to be fitted with a casement sash, hung to a solid frame, and opening inwards.

Draw a vertical section through A—A, to a scale of $1\frac{1}{2}''$ to a foot, showing a stone head and sill, a $1\frac{1}{4}''$ window board, and a $2''$ sash, which must be weather-tight.
(16.)

MAY, 1890.

FIRST STAGE OR ELEMENTARY EXAMINATION

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plan A represents one course at the end of a brick wall built in Flemish bond.

Draw to a scale of 1″ to a foot, making any alteration you think necessary. Also draw plan B, showing the arrangement of the bricks in the next course. (11.)

2. Give a sketch elevation showing a portion of a stone wall built of squared rubble worked up to courses. (11.)

*3. Elevation showing two 13″ square balks of timber halved together.

Draw the joint to a scale of ¾″ to a foot, but showing it tabled and secured by hardwood wedges, without any bolts. (11.)

*4. Plan of a beam cogged on to a wall-plate.

Give a section through *a—a* to a scale of 1″ to a foot. (11.)

*5. Elevation of a stone arch.

Draw to twice the scale, and write on it the names of all the different parts of the structure. (11.)

6. Explain by aid of sketches the meaning of the following terms :—wood plugs, lead dots, double quirk bead, wood lintel. (12.)

*7. Parts of a roof truss. One member of each kind being given.

Draw the truss to a scale of 4′ to an inch, writing down the name of the truss and of its different members, including any ironwork. (12.)

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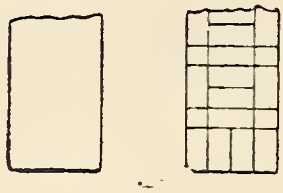

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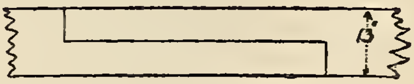

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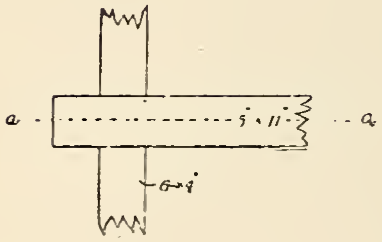

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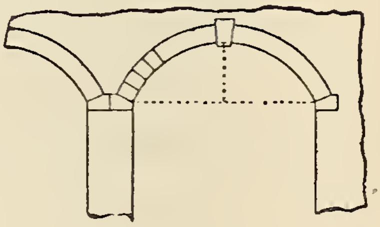

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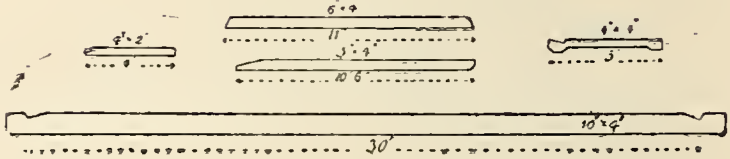

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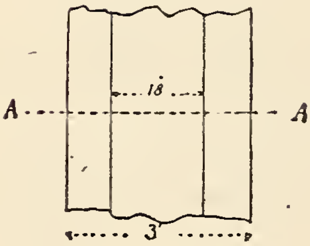

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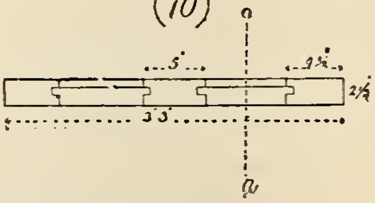

*8. Plan of part of an 18″ brick wall built in English bond, showing also the width of the bottom course of footings.

Draw the plan, to a scale of $\frac{3}{4}$″ to a foot, filling in the bricks in the 18″ course only.

Draw a vertical section through A—A, showing the arrangement of the bricks in the footings, no offset to be more than a $\frac{1}{4}$ brick. (13.)

9. A cast iron cantilever is 10″ in depth, and its flanges are respectively 4″ × $\frac{3}{4}$″ and 8″ × 1$\frac{1}{4}$″.

Draw its section in position, one-third full size. (13.)

*10. Horizontal section through a 4-panelled door, 7′ high.

Draw its outside elevation, and a vertical section through *a—a*, to a scale of $\frac{3}{4}$″ to a foot, showing the top panels bead butt, and the bottom panels bead flush.

(13.)

11. Draw, to a scale of 1$\frac{1}{2}$″ to a foot, a section through the eaves of a roof, showing 4$\frac{1}{2}$″ × 2″ rafters, with 3″ × 1″ battens, carrying 24″ slates.

Show four courses of slates, centre nailed, and laid to a 4″ lap. (14.)

12. An iron roof truss over a 24′ span consists of tee iron principals 3″ × 2$\frac{1}{2}$″ × $\frac{3}{8}$″, two angle iron struts, 1$\frac{1}{2}$″ × 1$\frac{1}{2}$″ × $\frac{3}{8}$″, and 5 tension rods of $\frac{7}{8}$″ diameter.

Draw the elevation of about half the truss, to a scale of 2′ to an inch. (15.)

13. Draw a cross section, to a scale of 1″ to a foot, through an 8″ lead gutter with step-flashings, formed at the end of a boarded and slated roof butting against the brick wall of another building. Also show the step-flashings in elevation. (16.)

14. Draw a vertical cross section, to a scale of 1$\frac{1}{2}$″ to a foot, through the foot of a wooden king-post, and a tie beam 5″ × 11″, showing all the details of a stirrup iron $\frac{3}{8}$″ thick, properly wedged up with gibs and cotters. (16.)

MAY, 1891.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plans of two successive courses of brickwork at the angle of a building.

Draw, to a scale of $\frac{3}{4}''$ to a foot, showing the bricks arranged in single Flemish bond. (11.)

*2. A represents the ends of two wall-plates at the angle of a building, to be halved together.

B represents the end of a wall-plate on a cross-wall, to be bevel halved on to a main wall-plate.

C represents the ends of two wall-plates to be connected by scarfing.

Draw, $\frac{1}{3}$ full size, the sections *a—a* through the finished joints; showing $4\frac{1}{2}'' \times 3''$ plates in each case. (11.)

*3. Elevation of part of a window opening in a brick wall.

Draw, to a scale of $\frac{1}{18}$, completing the elevation of the stone sill; and showing at A the bricks laid in English bond. (11.)

4. Give a vertical cross section through B—B, Fig. 3, to a scale of $\frac{1}{4}$, showing a $5'' \times 11''$ stone sill, weathered, throated, and grooved for metal tongue, and resting on 14″ brickwork. (11.)

*5. Part elevation at an angle of a stone building.

Draw, to a scale of $\frac{3}{4}''$ to a foot, showing a facing of random rubble, with hammer-dressed joints and no spalls; also cut stone quoins. (12.)

6. Draw, to a scale of $\frac{1}{96}$, a line diagram showing a queen-post roof truss for a span of 36 feet, with a rise of $\frac{1}{4}$ span.

Write their names against the different members.

State why a king-post truss should not be used for this span. (12.)

*7. Elevation of the head of a solid door frame.

Draw, to a scale of $\frac{3}{4}''$ to a foot, making any alteration you think necessary.

Give a section through A—A, showing a beaded frame, rebated for a $2\frac{1}{4}''$ door. (12.)

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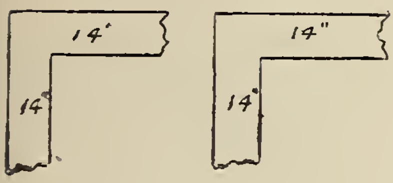

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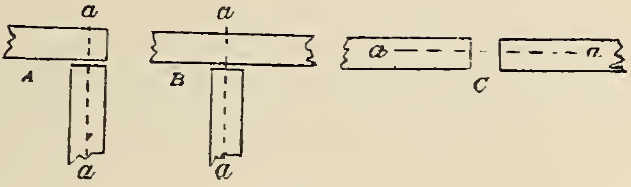

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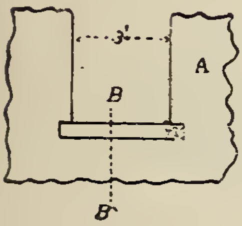

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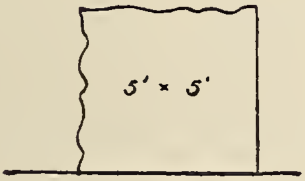

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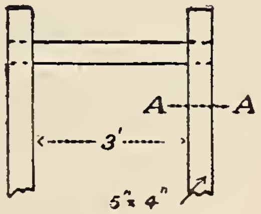

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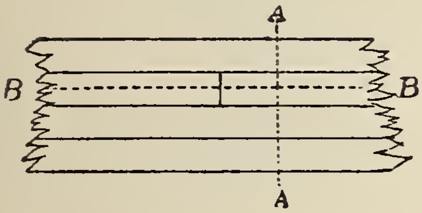

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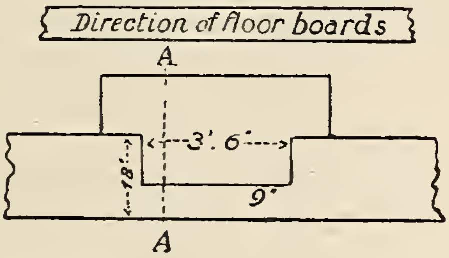

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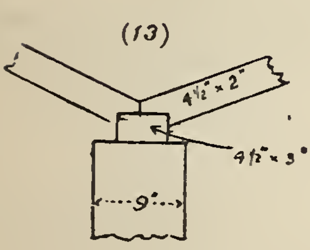

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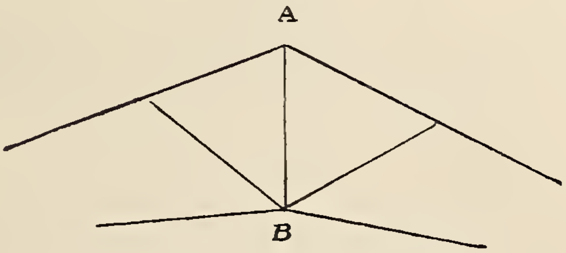

8. Show by sketches the meaning of the following terms in carpenters' work :—

Cross-grooving ; cockbead ; mortising and housing for rails, as applied to the head of a timber post ; panelled square and flat, and moulded one side. (13.)

9. Draw, to a scale of $3'$ to an inch, an elevation of a wooden collar roof, over a $16'$ span.

Rafters to be $4\frac{1}{2}'' \times 2''$, collar $4\frac{1}{2}'' \times 2''$, ridge board $8'' \times 1\frac{1}{2}''$, wall-plate $4\frac{1}{2}'' \times 3''$. Eaves to overhang one and a half brick walls $9''$. (13.)

*10. Plan of part of an ordinary wooden floor.

Draw, to a scale of $1\frac{1}{2}''$ to a foot, a section through A—A, showing $1\frac{1}{2}''$ battens, rebated and filleted ; also a section through B—B, showing a bevelled heading joint, and three joists, $11'' \times 2''$, spaced $12''$ apart. (14.)

11. Draw, to a scale of $\frac{1}{6}$, a vertical cross section through a solid window frame, fitted with a $1\frac{1}{2}''$ pivoted sash, $2'$ high, which is to be shown half open. (14.)

*12. Horizontal section through a fireplace on an upper floor.

Draw, to a scale of $1''$ to a foot, a plan, and also a cross section through A—A.

The plan to show how the wood floor is carried round the hearth, with the names of the different joists written against them.

The section to show the front and back hearth-stones, and how they are carried. (15.)

*13. Section through a gutter at the centre of an **M**-roof.

Draw, to a scale of $1\frac{1}{2}''$ to a foot, adding $\frac{3}{4}''$ slate and gutter boarding, and a lead gutter ; and, on one side, Countess slates laid to a $4''$ lap. (15.)

*14. Elevation of part of an iron roof truss.

Draw, to a scale of $3'$ to an inch, elevations of the joints at A and B, the different members consisting of tee irons $3\frac{1}{2}'' \times 3'' \times \frac{1}{2}''$ and $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times \frac{5}{8}''$, and $1\frac{1}{8}''$ round iron. (16.)

MAY, 1892.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Part elevation of both the end and face of a brick wall built in Flemish bond.

Draw to a scale of ¾″ to a foot, filling in the joints of the bricks by single lines. (11.)

2. Draw, to a scale of 2″ to a foot, a cross section through the top of a 14″ dwarf brick wall, showing a 5″ stone coping weathered and throated, with an iron rail, 1″ diameter, let into the top and run with lead. (11.)

*3. AA and BB are the ends of timber beams to be jointed together.

Draw, to a scale of ¾″ to a foot, showing at AA a butt joint with timber fish plates; and at BB a scarfed joint to take compression, secured with iron fish plates.

(11.)

4. Explain clearly by sketches the meaning of the following terms in connection with masonry joints :—

Metal cramp run with lead.
Bed plug.
Lead plug. (11.)

*5. Elevation of part of a window opening in a wall of random rubble built up to courses.

Draw, to a scale of ½″ to a foot, showing the stonework at A, finished with cut stone quoins, and completing the window head with an equilateral stone arch.

(12.)

6. Draw the following, to a scale of $\frac{1}{12}$:—

A cross section of a 16″ rubble sleeper wall, 2′ above ground level, carrying a 4½″ × 3″ plate.

An elevation of a rough inverted arch in two half-brick rings, for a 4′ opening, distributing the pressure over a concrete foundation. (12.)

*7. Section through 4 joists of a single floor.

Draw, to a scale of 1½″ to a foot, adding—1½″ floor boards, showing a bevelled heading joint—sound boarding and pugging—and lath and plaster ceiling. (12.)

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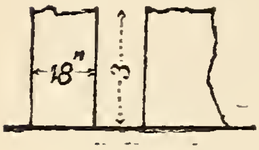

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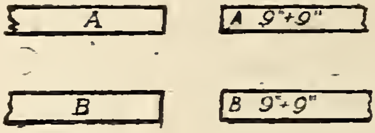

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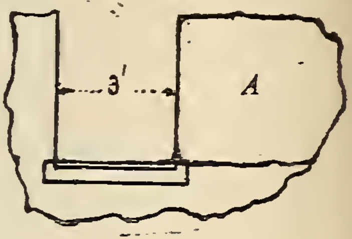

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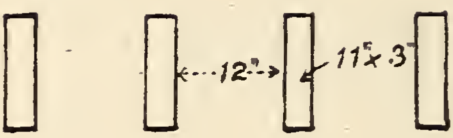

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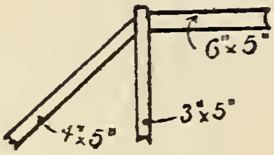

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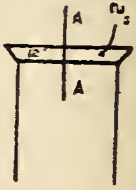

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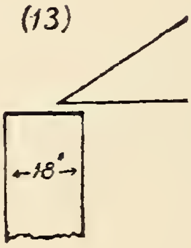

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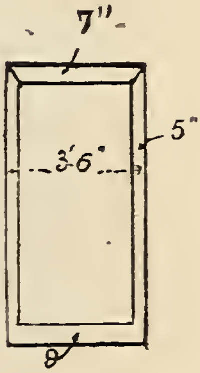

*8. Elevation of one of the joints at the head of an ordinary timber roof truss.

Draw the same properly, to a scale of $\frac{1}{6}$, showing the details of the joint, including a 2″ wrought-iron strap, and giving the names of the members shown. (13.)

9. Give sketches explaining the following terms :—

Tilting fillet and doubling eaves course.
Step flashing to brick chimney (13.)

10. Draw a section, to a scale of $1\frac{1}{2}''$ to a foot, through a double floor consisting of rolled iron girders $10'' \times 4\frac{1}{2}''$, common joists $2\frac{1}{2}'' \times 8''$, and $1\frac{1}{2}''$ battens, ploughed and tongued with hoop iron.

The section to show six battens. (14.)

11. Draw single line diagrams, to a scale of 8′ to an inch, showing the ordinary forms of timber roof trusses used for spans of 18′, 25′, and 40′ respectively.

Give the names of the trusses and of their different members. (14.)

*12. Front elevation of a gauged brick arch over a window opening in a 14″ brick wall.

Draw, to a scale of $1\frac{1}{2}''$ to a foot, a cross section through AA, showing a 3″ lintel, with a rough discharging arch in two half-brick rings ; also a $1\frac{1}{2}''$ head to window frame, with $\frac{3}{4}''$ inside, and $\frac{1}{2}''$ outside linings, $\frac{3}{4}''$ soffit lining, and the upper rail of a $1\frac{3}{4}''$ top sash. (15.)

*13. Elevation of one end of an iron roof truss, resting on a brick wall, the principal rafter being $4\frac{1}{2}'' \times 3\frac{1}{2}''$, and the tie rod $1\frac{1}{4}''$.

Draw, to a scale of $1\frac{1}{2}''$ to a foot, adding a cast-iron shoe bolted down to a 6″ stone template.

The tie rod to be adjusted by a screw nut at back of shoe. (15.)

*14. Outside elevation of a framed and braced outer door.

Draw, to a scale of $\frac{3}{4}''$ to a foot, making any alterations you consider necessary, and filling in with chamfered battens.

The joints to be shown by dotted lines, as well as the rails and braces not seen. (16.)

MAY, 1893.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

1. Give sketches, quarter full size, showing

(*a.*) Three $1\frac{1}{2}''$ floor *boards* with rebated joints, face nailed to a $9''$ joist.

(*b.*) Three $1\frac{1}{2}''$ floor *battens* with dowelled joints, secret nailed to a $9''$ joist. (11.)

*2. Plan of part of one course in a $2\frac{1}{2}$ brick wall, built in English bond.

Draw, to a scale of $1''$ to a foot, making any alteration you may think necessary, and show by dotted lines, on the same plan, how the bricks should be arranged in the next course. (11.)

*3. External elevation of a window opening in a brick wall.

Draw, to a scale of $1''$ to a foot, the head of the same, showing a straight gauged arch, and giving all the joints of the bricks composing it. (11.)

*4. Elevation of the foot of an iron king rod in a timber roof truss.

Draw, to a scale of $\frac{3}{4}''$ to a foot, adding $4\frac{1}{2}'' \times 2''$ struts, and any other details necessary to complete the joint. (11.

*5. Elevation of part of the end of a stone building just above the ground line.

Draw, to a scale of $\frac{1}{2}''$ to a foot, showing a rusticated stone plinth $22''$ high, ashlar quoins, and coursed rubble walling. (12.)

*6. A is the section of a wall-plate carrying the end of a joist.

Draw to the same scale, showing the joist cogged down to the plate.

B is the foot of a wooden upright, secured by fox-wedging to a wood sill sunk in a concrete floor.

Draw, to the same scale, showing the details of the joint in section. (12.)

7. Give sketches explaining the use of the following:—

Lead tingles.
Tile creasing.
Stone corbels. (12.

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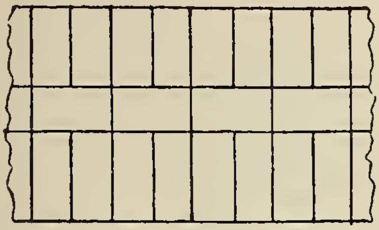

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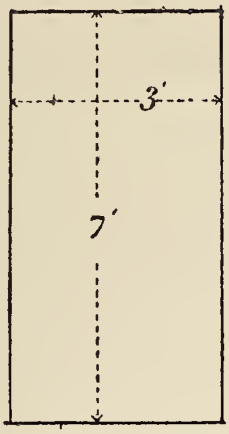

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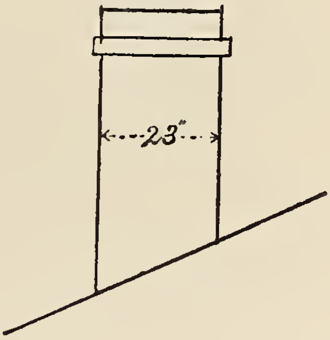

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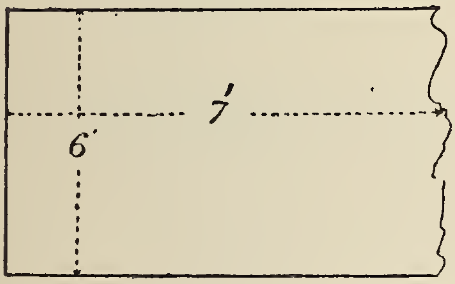

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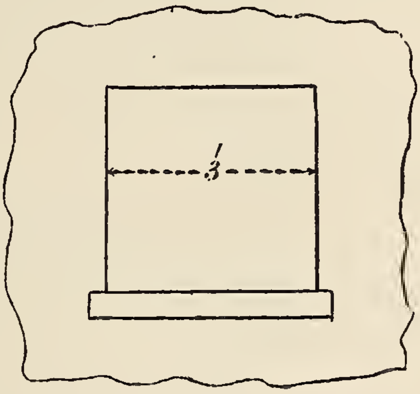

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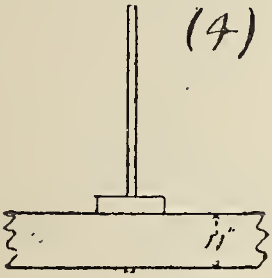

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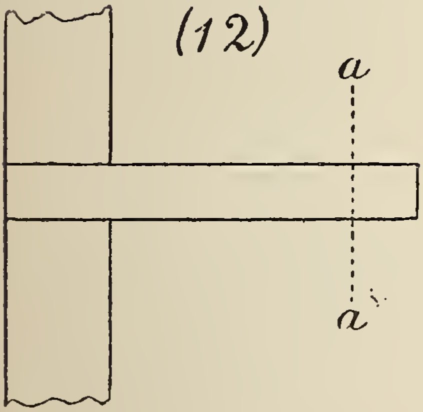

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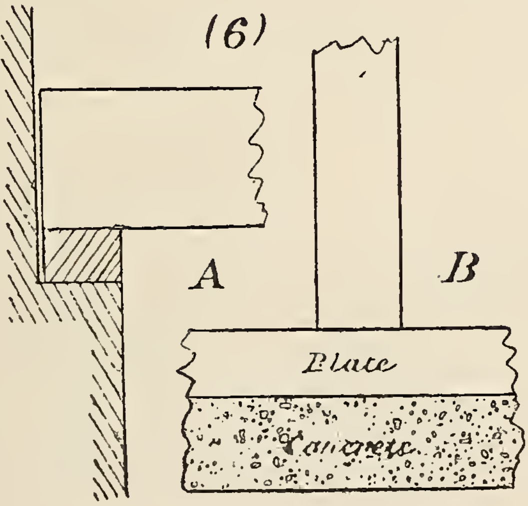


8. Draw, to a scale of $\frac{3}{4}''$ to a foot, a cross section of a 9″ brick sleeper wall, 18″ high, carrying a wooden floor, the joists being 6″ × $2\frac{1}{2}''$. (13.)

9. Draw, to a scale of 2′ to an inch, the elevation of about one-half of a roof truss for a 26′ span, showing the following details, the rise being quarter the span:

Wall plates, $4\frac{1}{2}''$ × 3″.
Principals, 5″ × 4″.
Tie-beam, 11″ × 5″.
Struts, 4″ × 3″.
King post, 5″ × 4″.
Purlins, 8″ × 5″.
Pole plates, 8″ × 3″. (13.)

*10. Elevation of a brick chimney shaft, rising through a slate roof.

Draw, to a scale of $\frac{3}{4}''$ to a foot, a cross section through the shaft, showing the details of the leadwork and fixing, including two courses of 18″ slates, both above and below the shaft. (14.)

*11. Elevation of the back of a ledged and braced battened door.

Draw, to a scale of $\frac{3}{4}''$ to a foot, showing it hung to a 2″ frame, with cross-garnet strap hinges. (14.)

*12. Elevation of a cast-iron cantilever, 9″ deep, built into a wall.

Draw, one-third full size, a vertical section through *a—a*, one flange being 6″ × 1″, and the other $2\frac{1}{2}''$ × $\frac{5}{8}''$; also an end elevation of the wall end of the cantilever. (15.)

13. Draw, quarter full size, an elevation of the joint at the head of a king rod in an iron roof truss, from the following details:—

King rod, $\frac{3}{4}''$ diameter.
Rafters of tee-iron, $2\frac{1}{2}''$ × 3″ × $\frac{3}{8}''$.
Slope of roof, 30°. (15.)

14. Draw a vertical cross section, to a scale of $1\frac{1}{2}''$ to a foot, through the bottom of a window opening, showing an oak sill 7″ × 3″, weathered and grooved for iron tongue; a stone sill, 9″ × 5″, weathered, throated and grooved, and resting on 14″ brickwork; a $1\frac{1}{2}''$ window board; the wall rendered inside, and finished at floor with $1\frac{1}{4}''$ torus moulded skirting 9″ high, scribed to floor. (16.)

MAY, 1894.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Section showing the footings of a brick wall resting on a bed of concrete 2′ thick.

Draw, to a scale of ¾″ to a foot, showing the joints of the brickwork in English bond, and making any alteration you think proper. (11.)

*2. Plan of a course of brickwork at the angle of a wall built in single Flemish bond.

Draw to a scale of 1″ to a foot, showing a heading course on the inner face of the wall. (11.)

3 Give sketches showing the meaning of the following terms :—

Spandrils of an arch.
King closer.
Pole plate.
Channel iron. (11.)

*4. Section through part of a stone wall of a dwelling house, showing a projecting string course.

Draw to a scale of $\frac{1}{12}$, showing rubble work built up to courses, and making any alteration you think advisable. (11.)

*5. Elevation of part of a 14″ dwarf brick wall with a saddle back stone coping 5″ thick, throated both sides and finished with an iron railing, the bars being 1″ square.

Draw, ¼ full size, a vertical section through A—A, showing clearly how the rails are secured to the coping, and filling in four courses of brickwork. (12.)

*6. Elevation of the joint at the foot of a king post in a wooden roof truss.

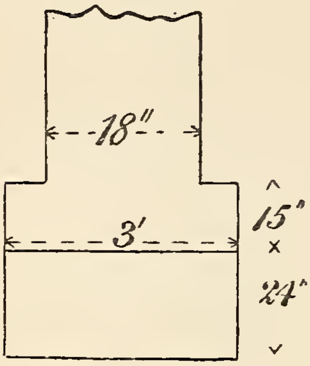
Draw, ¼ full size, a section through A—A, showing all the details of a stirrup iron properly keyed up with gibs and cotters. (12.)

*7. Section of a beam which is to be lengthened by a scarfed joint, without any fish-plates or bolts.

Give, to a scale of $\frac{1}{12}$, elevations of two forms of joint :—

(*a*) Supposing the beam to be exposed to tension only.

(*b*) Supposing the beam to be exposed to both tension and compression. (12.)



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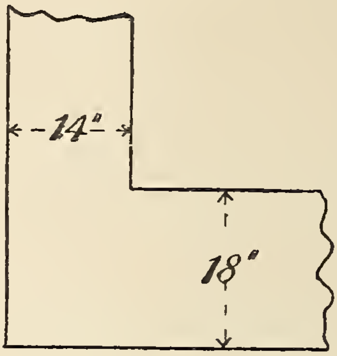

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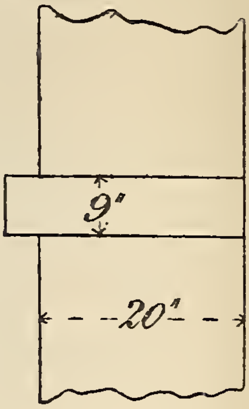

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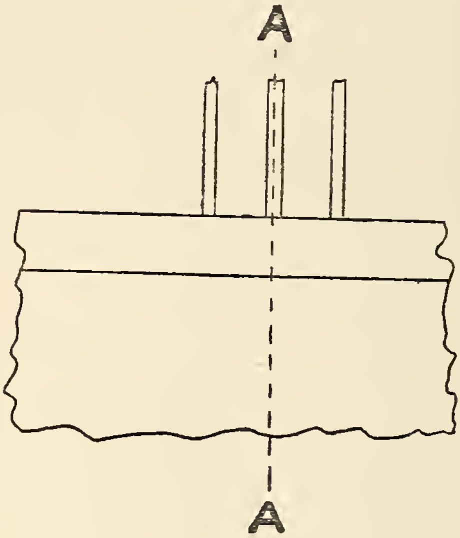

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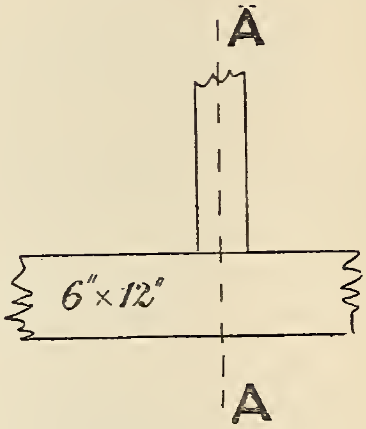

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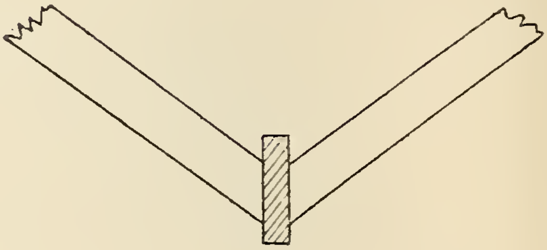

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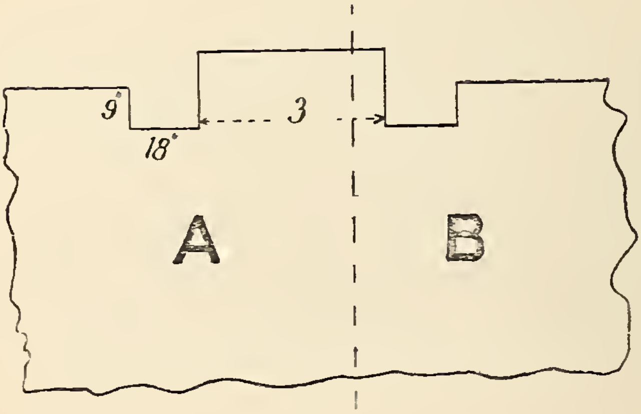

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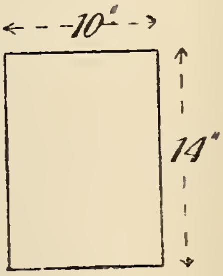

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8. Draw, to a scale of $\frac{1}{48}$, skeleton diagrams showing the difference between the following descriptions of open timber roofs in their simplest forms. All members below the slate boarding to be indicated, with their names.

   (*a*) A couple roof.
   (*b*) A collar beam roof.
   (*c*) A king post roof.

   The spans to be 25′, 16′, and 12′ respectively. (13.)

9. Give a cross section, to a scale $\frac{3}{4}''$ to a foot, through 2 binders of a double floor, from the following details:—

   Fir binders 10″ × 12″, at 9′ centres.
   Joists 7″ × 2″.
   Ceiling joists 4″ × 2″.
   The total depth of the floor to be 16″, the ceiling being level throughout. (13.)

10. Give an elevation and central cross section, to a scale of 2′ to an inch, showing the centering you would use in turning a flat segmental gauged brick arch over a 4′ window opening, and a semi-circular rough brick arch, 3′ deep, over a 9′ span. Give the names of the different parts. The arches to be shown, but the joints of the brickwork need not be filled in. (14.)

*11. Plan of part of a first-floor room.

   Draw, to a scale of $\frac{1}{24}$, showing on the portion marked A back and front hearthstones and the floor laid in batten widths; and on the portion marked B, the naked floor, joists 10″ × 3″, trimmer and trimming joist 10″ × 4″. (14.)

*12. Section of a valley in a slate roof.

   Draw, correctly, to a scale of $\frac{3}{4}''$ to a foot, giving the details of the lead gutter and slates, at least 3 courses of Countess slates on one side of gutter. (15.)

13. The king trusses of an iron roof are constructed of the following sections:—

   $\frac{5}{8}''$ and 1″ round iron.
   4″ × 3″ × $\frac{1}{4}''$ tee iron.
   2″ × 2″ × $\frac{1}{4}''$ angle iron.

   Give an elevation, half full size, of the joint at the foot of the king rod, and at the head of a strut. (15.)

14. Draw a horizontal section through a little more than half of an external doorway in a 20″ stone wall, with ashlar quoins and rendered on inner face.

   The section to be to a scale of 1″ to a foot, through one panel of a 2″, 6-panel door, hung folding, bead flush outside and square and flat at back, to proper solid frame, with plain linings and chamfered architraves.

   Internal width of frame to be 3′ 9″. (16.)

MAY, 1895.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plans of two successive courses of a brick pier.

Draw, to a scale of 1″ to a foot, showing the bricks laid in English bond. (11.)

*2. Section of a dwarf brick wall.

Draw to a scale of $\frac{3}{4}''$ to a foot, showing the joints of the brickwork below the ground, adding the footings and a proper stone saddle-back coping 17″ wide. (11)

*3. Elevation of part of the end of a stone building, in irregular coursed or snecked rubble, the quoins being hammer dressed with drafted margins.

Draw, to a scale of $\frac{3}{4}''$ to a foot. (11.)

*4. A and B show two bed joints in Ashlar work.

Draw A, showing the meaning of a hollow joint, with its probable results.

Draw B, showing the probable effects of a slack joint at back, packed with spalls. (11.)

*5. Sections of the sill and one of the studs of a lath and plastered framed partition.

Draw, to a scale $\frac{1}{4}$ full size, a vertical cross section of the joint at the foot of the stud.

State what distance you would place the studs apart, and why. (12.)

6. Give a cross section, to a scale of $\frac{1}{3}$ full size, through four $1\frac{1}{4}''$ floor battens, showing the following joints—rebated—rebated and filleted—ploughed and tongued. Put its name against each. (12.)

*7. Section of the lower half of a cast-iron girder 14″ deep.

Draw, $\frac{1}{4}$ full size, making any alteration you think necessary, and adding the upper part of the section.

(12.)

*8. The details of an iron roof truss, for a 25′ span.

Give, to a scale of $\frac{1}{30}$, an elevation of at least half of the truss. (13.)

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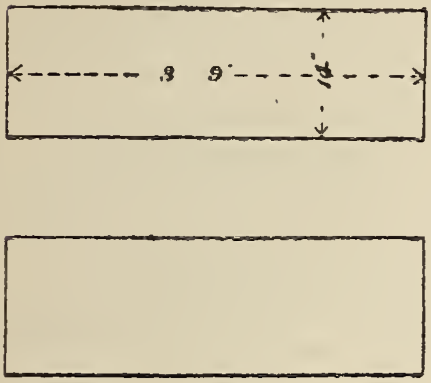

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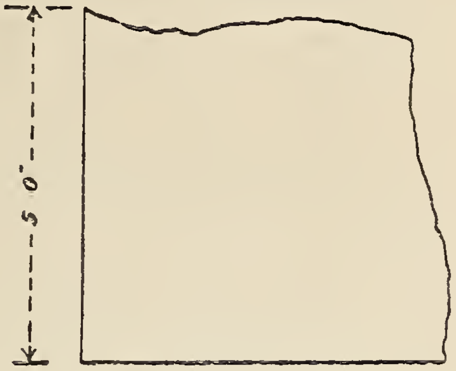

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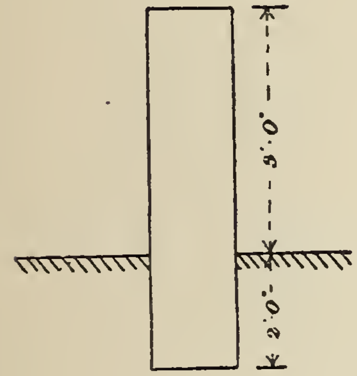

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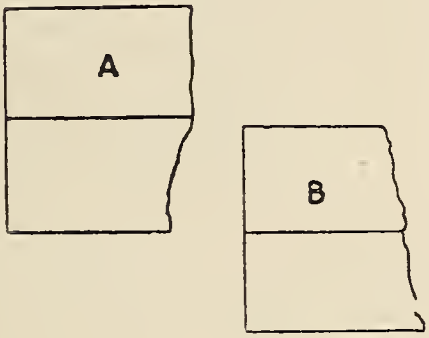

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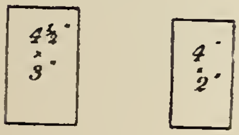

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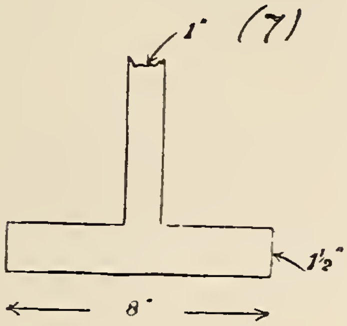

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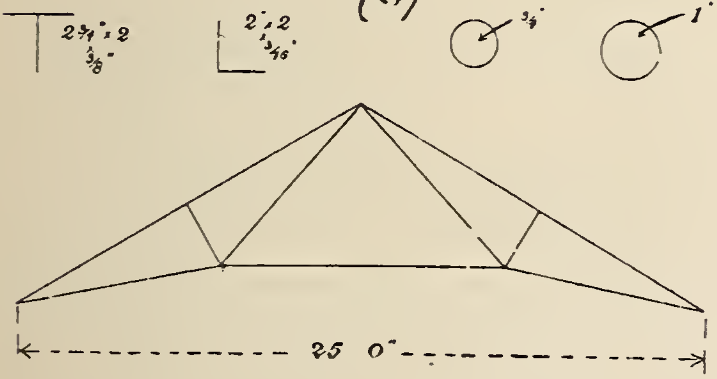

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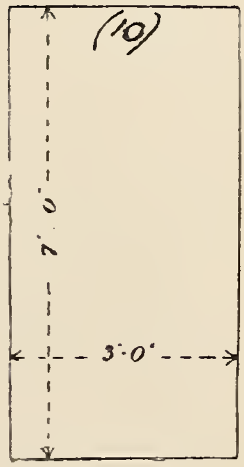

9. Draw, to a scale of $\frac{1}{12}$, the back elevation of the head of a 3′ window opening in a brick wall, with $4\frac{1}{2}''$ reveals, a plain stone head, wood lintel, and common discharging arch.

The joints of the brickwork to be shown only on the right half of the elevation. The bond to be English. (13.)

*10. Elevation of a 6-panel door, framed square and flat.

Draw, to a scale of $\frac{3}{4}''$ to a foot, showing all the details of construction, and writing their names on the different parts. (14.)

11. Give, to a scale of $\frac{1}{18}$, a cross section through 2 girders of a framed floor constructed as follows :—

Girders, 12″ × 10″, and 8′ apart.
Binders, 8″ × $5\frac{1}{2}''$.
Bridging joists, 6″ × 2″.
Ceiling joists, 3″ × 2″. (14.)

12. Give a vertical cross section, to a scale of $\frac{1}{6}$, showing, both in section and elevation, all the details of a $1\frac{1}{2}''$ centre pivoted swing sash, with a 3″ × $2\frac{1}{2}''$ solid frame set in a 9″ brick wall. The sash to be 2′ 3″ high, and shown half open. (15.)

13. Draw, to a scale of an inch to a foot, a vertical cross section through the eaves of a wooden roof, showing the end of the truss carried on a 9″ wall. Scantlings as follows :—

Wall plate, $4\frac{1}{2}''$ × 3″.
Tie beam, 10″ × 5″.
Principal, 5″ × 4″.
Pole plate, 7″ × 4″.
Rafters, 4″ × 2″.

Three courses of Countess slates to be shown centre-nailed on $2\frac{3}{4}''$ × $\frac{3}{4}''$ battens.

The eaves to be finished with a 4″ half round gutter secured to a $\frac{3}{4}''$ deal fascia board. (15.)

14. Draw, $\frac{1}{4}$ full size, a horizontal section through one side of a sash frame in a 14″ brick wall, including the stile of the lower sash, which is to be 2″ ovolo moulded.

Put their names against the different parts. (16.)

MAY, 1896.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plans of two consecutive courses at the end of a brick wall built in Flemish bond.

Draw, to a scale of $\frac{1}{12}$, showing the joints of the brickwork, and marking by thick lines any portions of the joints which run unbroken down the wall. (11.)

*2. Vertical cross section of a wall with a stone coping.

Draw, to a scale of 2″ to a foot, a longitudinal section through AA, showing the coping stones cramped together, and the joints of the two top courses of bricks, laid in English bond.

State the materials you would prefer to use for the joint. (11.)

*3. Sections of a trimmer and a bridging joist for a single floor.

Draw, to a scale $\frac{1}{4}$ full size, a cross section through the trimmer, showing the details of the joint between it and the bridging joist. (11.)

4. A timber beam, 12″ × 14″, is to be strengthened by a $\frac{3}{4}$″ iron flitch.

Give, to a scale of $\frac{1}{6}$, a cross section of the finished girder, showing the annual rings of the timber, also a part elevation sufficient to show the arrangement of the bolts. (11.)

*5. Part elevation of a stone wall built in random rubble, and at A a lacing course of three courses of bricks laid in Flemish bond.

Draw to a scale of $\frac{1}{2}$″ to a foot. (12.)

6. Show clearly, by sketches, the meaning of the following terms :—

Match boarding.
Flush bead.
Lead tingle.
Doubling eaves course. (12.)

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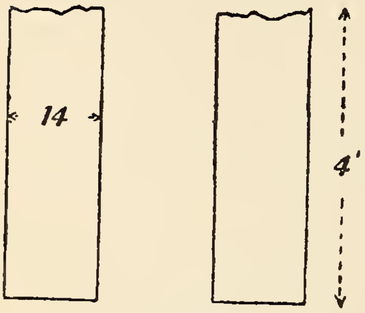

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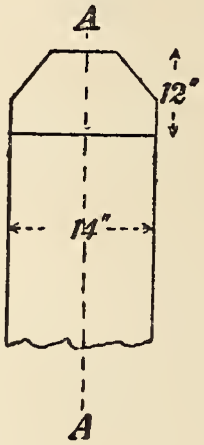

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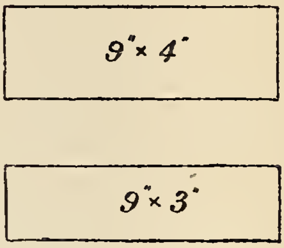

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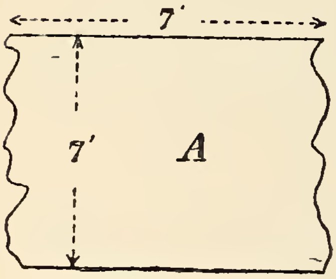

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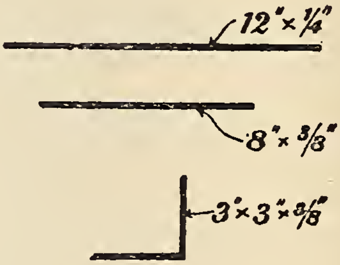

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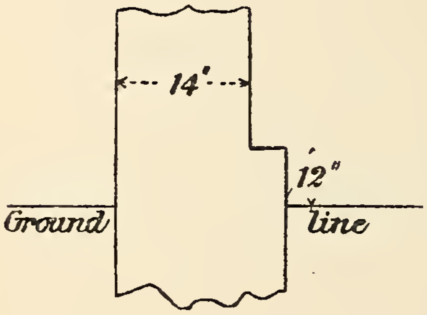

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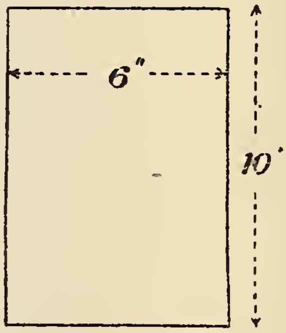

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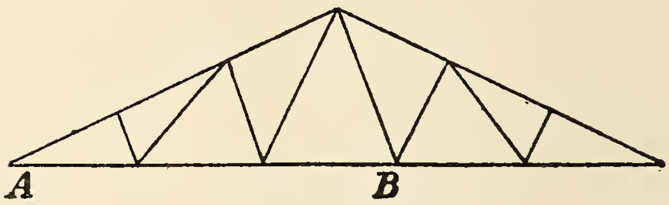

*7. Give, to a scale $\frac{1}{4}$ full size, a cross section of a wrought iron girder built up of the sections indicated by the line diagrams.

Show a part elevation, about 9″ long, with the rivets at a 4″ pitch. (12.)

*8. Cross section of the lower portion of the brick wall of a house.

Draw, to a scale of $\frac{3}{4}$″ to a foot, showing a portion of the floor, with a $4\frac{1}{2}$″ × 3″ plate, 9″ × $2\frac{1}{2}$″ joist, and $1\frac{1}{2}$″ battens.

Add brick footings to the wall, standing on 12″ of concrete, the bottom of the concrete being 3′ below ground level. (13.)

9. Give a vertical section, $\frac{3}{4}$ full size, through a plumber's flange joint in an inch lead pipe passing through a $1\frac{1}{4}$″ floor board. (13.)

10. Draw a line diagram, to a scale of $\frac{1}{60}$, of an ordinary timber roof truss suitable for a 25′ span, showing the purlins, poleplate, ridgeboard, and common rafters, in their proper positions. (14.)

11. Draw, to a scale of $\frac{3}{4}$″ to a foot, both the front and back elevation of a $1\frac{1}{4}$″-ledged and braced battened door, 3′ × 6′ 6″.

Give a full-sized section through a joint between two of the battens, showing it ploughed and tongued, chamfered one face, and beaded on the other. (14.)

*12. Cross section of a stone to be formed into an ordinary window-sill.

Draw, to a scale $\frac{1}{4}$ full size, the finished section, weathered, throated and grooved, and fixed in a 14″ brick wall. Two courses of brickwork to be shown below the sill, and two courses in elevation above the stool. (15.)

13. Draw, to a scale of 1″ to a foot, a vertical cross section through a fire opening on an upper floor, showing depth of opening 14″, back 9″, a brick trimmer arch, and a 9″ × 4″ trimmer, also front and back hearths. (15.)

*14. Line diagram of an iron roof truss.

Show, by sketches, the sections you would adopt for the different members, and give full details of the joint you would use at A and B. (16.)

MAY, 1897.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plan of part of a brick wall at ground level, showing the footings and 9″ concrete foundations, the total depth below surface being 2′ 6″.

Draw, to a scale 1″ to a foot, a section through *a—a*, showing the joints of the brickwork by single lines. (11.)

*2. The head of an oak gatepost and the end of a rail which is to be housed, mortised, and fox-wedged into it.

Draw to a scale of $\frac{3}{4}$″ to a foot, showing all the details of the joint before connecting up. The post to be shown in section. (11.)

3. Explain by sketches the meaning of the following terms :—

Joggle joint.
Spandrils of arches.
Lead plug.
Step flashing. (11.)

4. Draw, to a scale $\frac{1}{3}$ full size, a rolled iron joist 10″ × $4\frac{1}{2}$′, the web being $\frac{3}{8}$″, and the flanges averaging $\frac{3}{4}$″. (11.)

*5. A joint in a timber tiebeam.

Draw to a scale of an inch to a foot, making any addition or alteration you think necessary to ensure a secure joint, and give the name of the joint.

Draw a similar joint, capable of resisting both direct tension and compression. (12.)

*6. Plans of two courses of brickwork at the angle of a building built in English bond.

Draw to a scale of $\frac{3}{4}$″ to a foot, showing the joints by single lines, and marking by thicker lines those portions of the joints which run unbroken down the wall. (12.)

*7. Sections of the joists and boards of a common floor.

Draw, to a scale of $1\frac{1}{2}$″ to a foot, a cross section through three of the joists, showing the boards with a rebated and tongued heading joint.

Between one pair of joists show 2″ × $1\frac{1}{2}$″ herring-bone struts, and between the other pair sound boarding and pugging. (12.)

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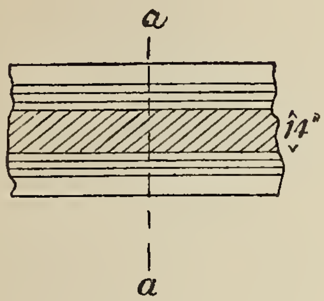

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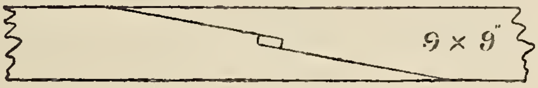

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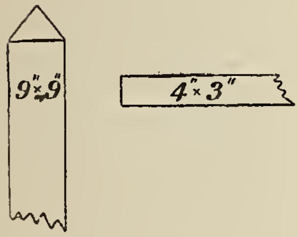

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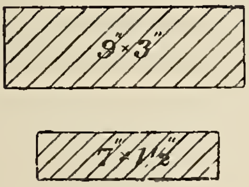

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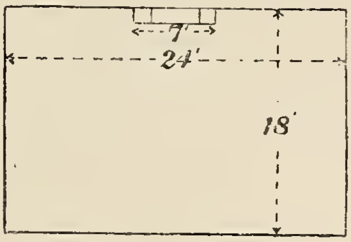

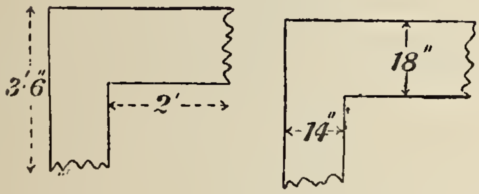

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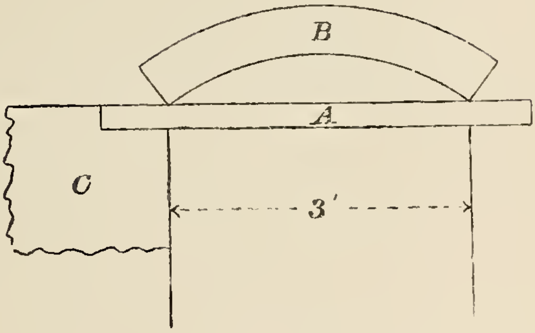

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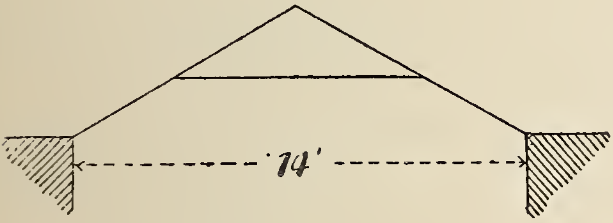

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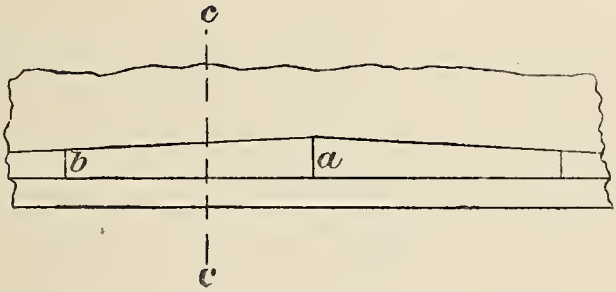

*8. Plan of a room which is to have a double floor.

Draw to a scale of $\frac{1}{60}$, showing by single lines the arrangement of the different members of the floor and writing their names against them.

Give a section, $\frac{1}{4}$ full size, through two of the floor battens, showing them laid with rebated and filleted joints. (13.)

9. Draw a horizontal section through the jamb of an external doorway in a store, showing a 14″ brick wall, with bullnose dressings outside, 5″ × 4″ solid frame, rebated and beaded, and the hanging stile of a $2\frac{1}{4}$″ framed and braced door, including two rebated and beaded battens of same. (13.)

*10. Internal elevation of the head of a window opening in a stone building.

Draw to a scale of $\frac{1}{12}$, making any alteration you think necessary.

Give the names of the parts A and B, and at C show rough rubble built up to 20″ courses. (14.)

11. Draw an elevation of a six-panel door 7′ × 3′, writing their names on the different parts, and showing the difference between panels square and flat, bead butt, and bead flush, stating which is which. Also show by dotted lines how the parts are framed together. (14.)

*12. Line diagram of a timber roof with a rise of $\frac{1}{3}$ the span, the rafters being $3\frac{1}{2}$″ × $2\frac{1}{2}$″, and the collars $4\frac{1}{2}$″ × 2″.

Draw, to a scale of $\frac{1}{2}$″ to a foot, a little more than halt of same, showing how it would rest with overhanging eaves on a 9″ brick wall.

The joint between the collar and the rafter is to be shown in detail, and must be made so as not to weaken the rafter.

Give the name by which the roof is known. (15.)

*13. Plan of part of a lead roof gutter behind a brick parapet, showing the position of the joints in the lead.

Draw, to a scale $\frac{1}{4}$ full size, cross sections through *a* and *b*, giving full details of the joints. Also draw a section through *c*—*c*, including three courses of Countess slates on 1″ boards. (15.)

14. Draw, to a scale of $\frac{1}{48}$, an elevation of a little more than half of an iron roof truss for a 30′ span, the rise being $\frac{1}{4}$ the span, from the following data :—

Principal tee-iron rafters 4″ × 3″ × $\frac{3}{8}$″ ; three vertical rods of $\frac{3}{4}$″ and $\frac{1}{2}$″ metal ; four inclined angle iron struts, 2″ × 2″ × $\frac{3}{8}$″ and $2\frac{1}{4}$″ × $2\frac{1}{4}$″ × $\frac{3}{8}$″.

Tie rod 1″ diameter, with a 9″ camber. (16.)

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